New Process in the Solid-Liquid Separation
FIMA Suspension Dryer with Counter Impulse Technology

Safe production even with a wide grain size spectrum

It is common practice to use centrifuges and dryers for solid-liquid separation. Conventional centrifuge systems will fail with certain product properties, such as a wide grain size spectrum with a large fraction of fine grains. Thanks to a new production method, it is now possible to get around these difficulties in a safe and reliable way.

Known production sequences in a FSD Suspension Dryer:

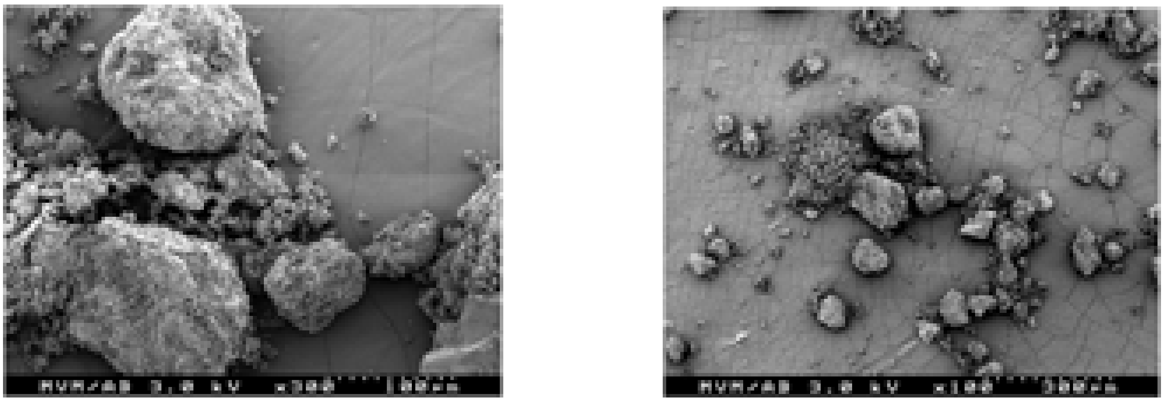
The suspension is filled into the filter drum through the drive shaft [Fig. 1].

[Fig. 1]
Filling a centrifuge dryer

In the centrifugal field, the solid material is retained by the multi-layer filter and the mother liquor passes through the product cake. In the following step, the filter cake is washed. After the washing process, centrifugation starts for mechanical dewatering. The residual capillary rise can be reduced by applying an overpressure.

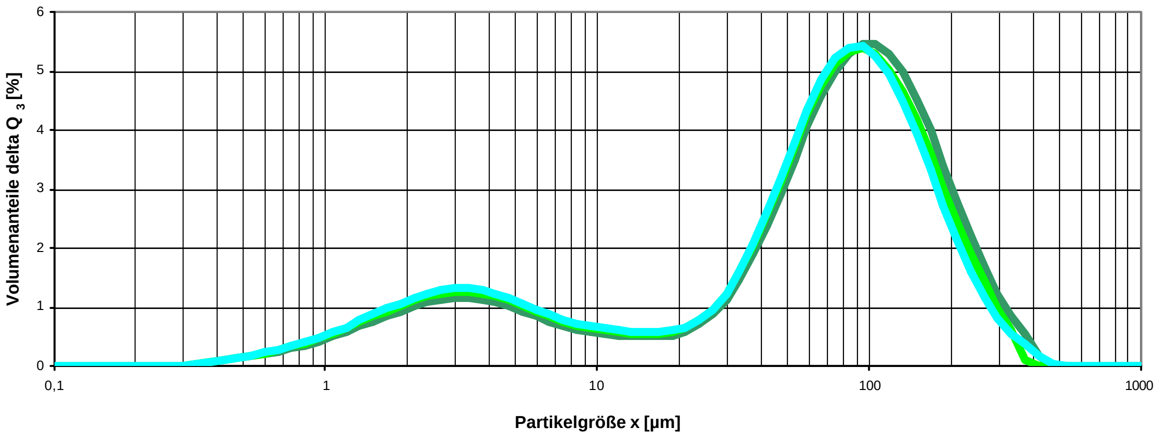
[Fig. 2]
Fluid bed drying

In the next step, an extremely efficient and gentle thermal drying process with fixed bed drying and / or fluid bed drying starts:



[Fig. 3] Product with a very wide grain size spectrum under REM at the Institute of Mechanical Process Engineering and Mechanics University of Karlsruhe

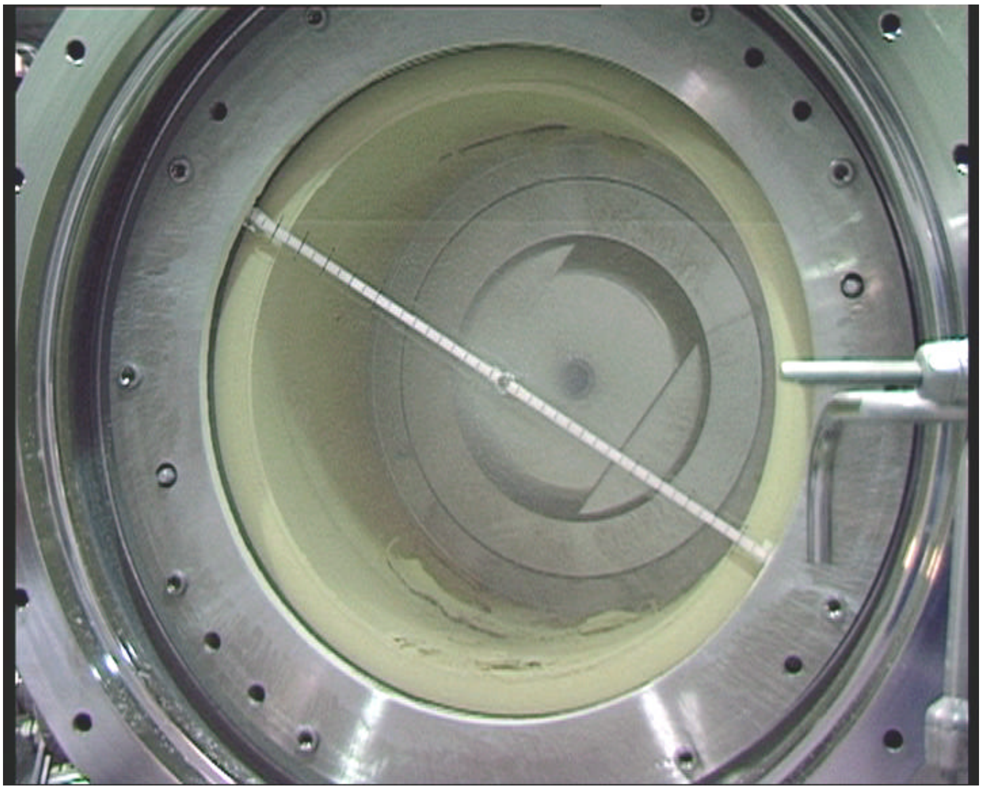
Centrifuging and drying of products with a wide grain size spectrum [Fig. 3] and a large fraction of fine grain [Fig. 4], i.e. with a bimodal distribution is not possible by using common processes, or only with considerable effort.



[Fig. 4] Bimodal Distribution with high Content of Fines

During filter cake forming, the interstitial spaces of coarser particles are filled with fine-grained material, thus preventing the liquid phase from draining off during filling. Consequently, the filtrate passes through the product cake only very slowly, the ring of liquid gets higher and is reduced extremely slowly [Fig. 5a, b]. Additionally, as the ring of liquid remains in the process chamber for a rather long time, an undesired sedimentation is caused.

[Fig. 5a]
Sedimentation in the ring of liquid of the suspension dryer



[Fig. 5b]
Greasy film caused by sedimentation; became detached during drying. Tests performed at the Institute for MPE, University of Karlsruhe (TH)

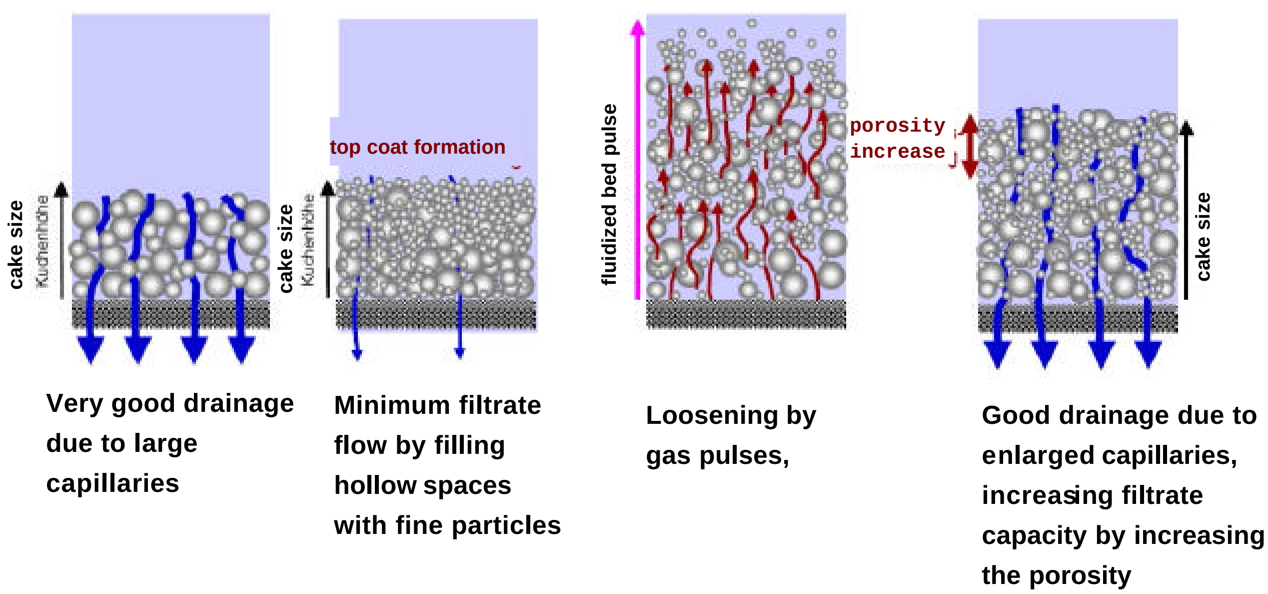
Due to the different surface-to-mass ratio, larger particles will sediment faster than finer particles in the centrifugal field outward on the filter cake. The smallest fraction floats longer in the ring of liquid and, at the end, the particles deposit on the cake, leaving an impermeable greasy film.

Fig. 5b shows the chipped off greasy film that became detached from the rest of the cake during the drying process. As this greasy film has low gas permeability, economical drying is no longer possible. The drying times are considerably longer than those required for porous filter cakes. Dewatering of the cake in a fixed bed drying process will only be possible after detachment of the greasy film. Furthermore, the cake is no longer homogenous as the fine particles are bound together, forming fine small plates which are in the majority of cases so hard that mechanical assistance is required to dissolve them into finest dust to be evenly distributed over the rest of the powder.

During washing and centrifuging, too, the filtrate speed is very low, which considerably increases process time. Better results cannot be achieved by increasing the rotation speed, i.e. by an increased C-value or overpressure, since the product cake is being highly compressed and even becomes less permeable to the drying gas during further fixed bed drying.

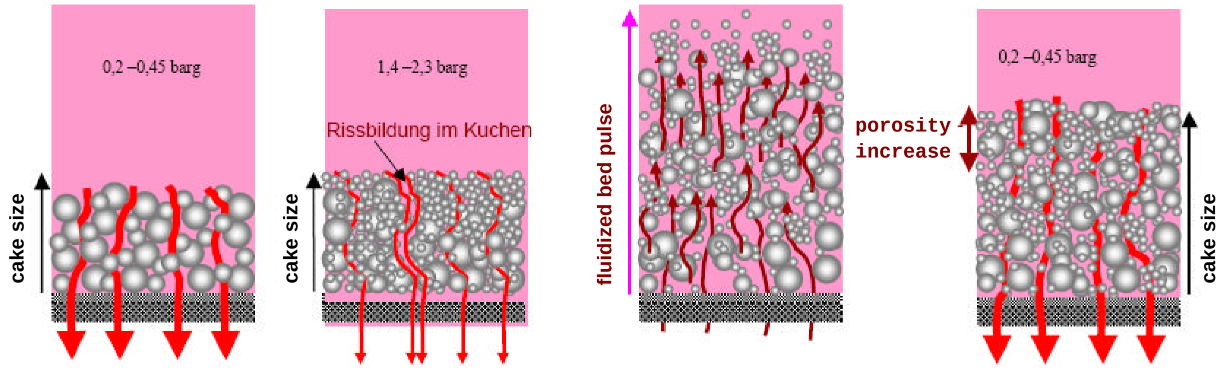
This is where the new filtering and drying variant comes in: Thanks to the counter impulse method, the product cake can be loosened in every process step. During filling, washing and centrifuging [Fig. 6], the C-value is kept to a minimum, a ring of liquid is not produced, the risk of sedimentation and forming of a greasy film is excluded. With the counter impulse method, the product cake is not dislodged either during dewatering [Fig. 6]. With each rotation of the drum, each nozzle shoots into a different opening in the bottom of the drum.

Filtration with different particle size distribution



[Fig. 6] Counter impulse fitration, schematic representation at the Institute for MPE, University of Karlsruhe (TH)

Drying with different particle size distribution



Very good gas permeability, uniform drying

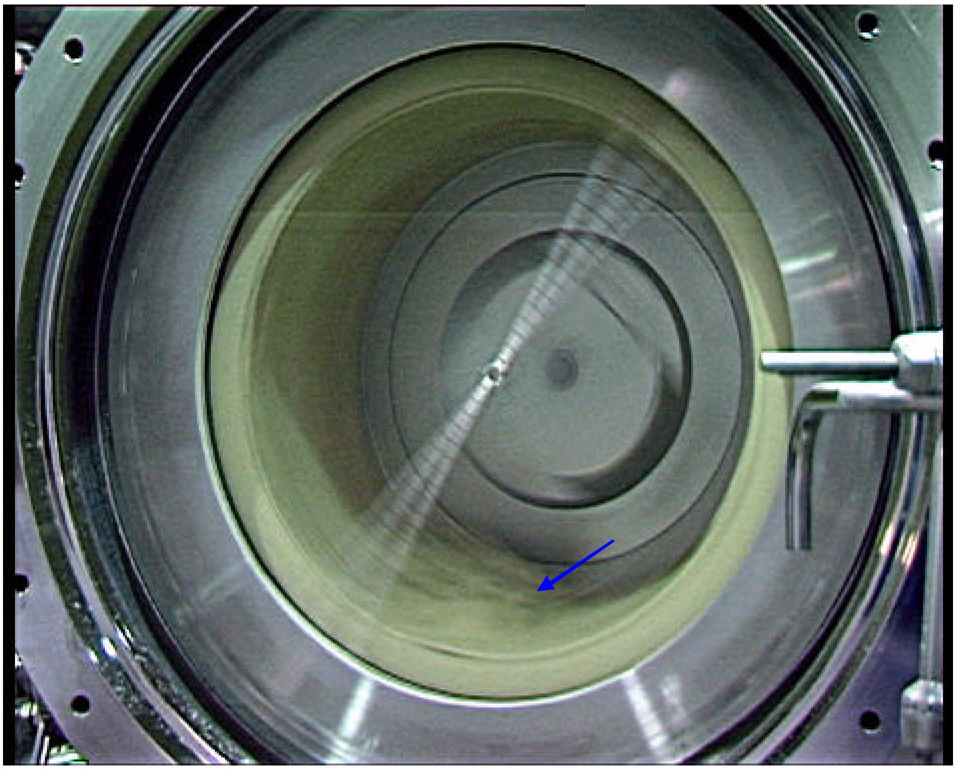
High flow resistance, crack building in the cake, high compaction of the product

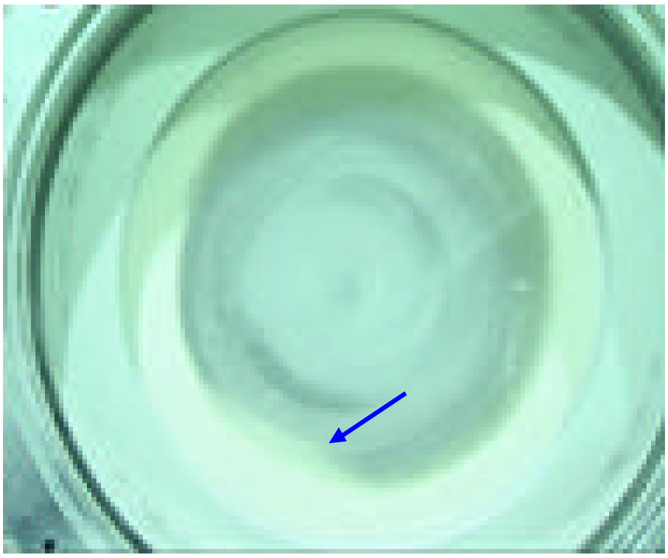
Loosening by gas pulses, fluidized bed pulse, no rolling up of product parts

Good flow due to big capillaries, increase of the drying capacity by increasing the porosity

[Fig. 7] Counter impulse drying, schematic representation at the Institute for MPE, University of Karlsruhe (TH)

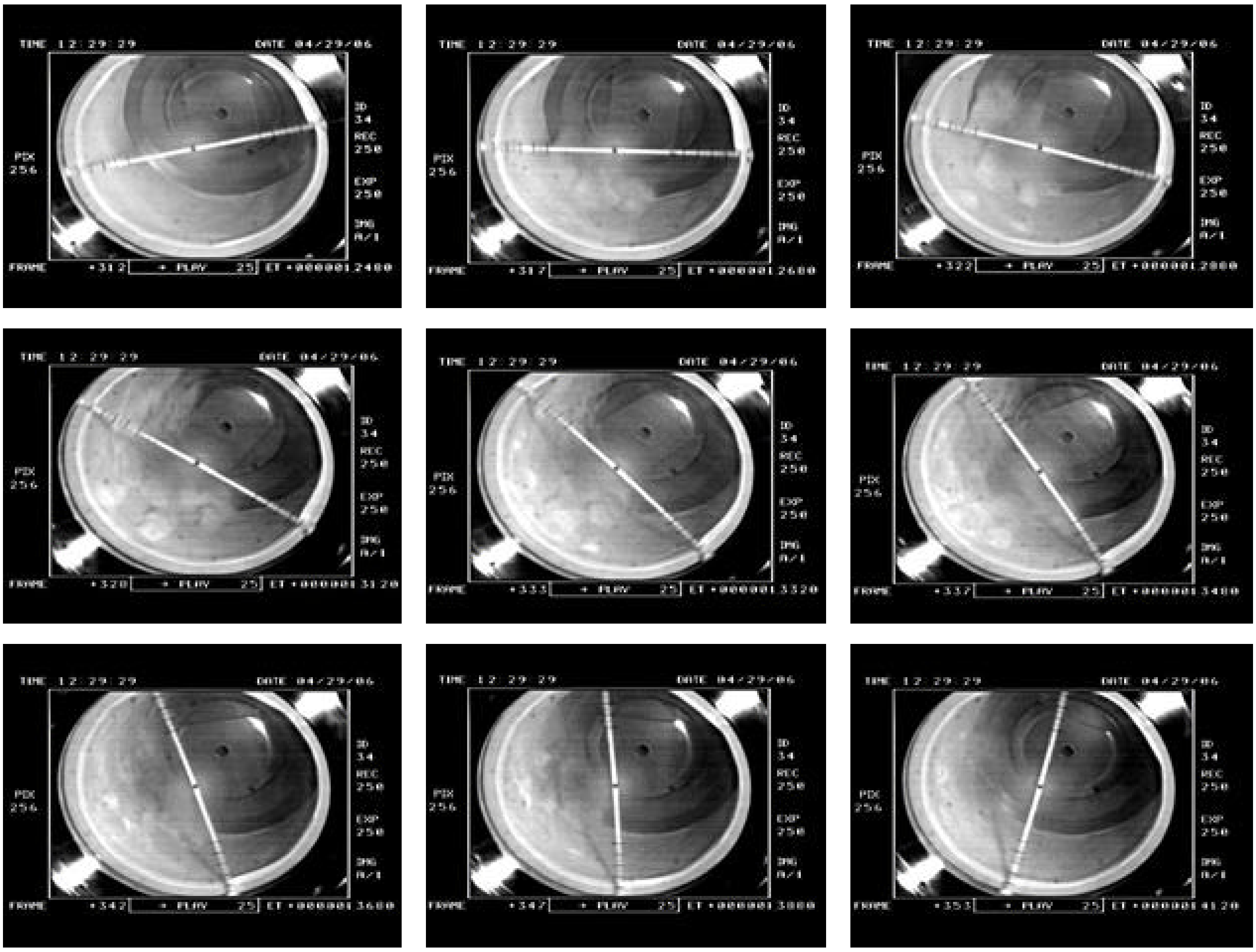
[Fig. 8a]
Counter impulse method with wet product and low porosity.





[Fig. 8b]
Counter impulse method with slightly dewtered product and medium porosity.

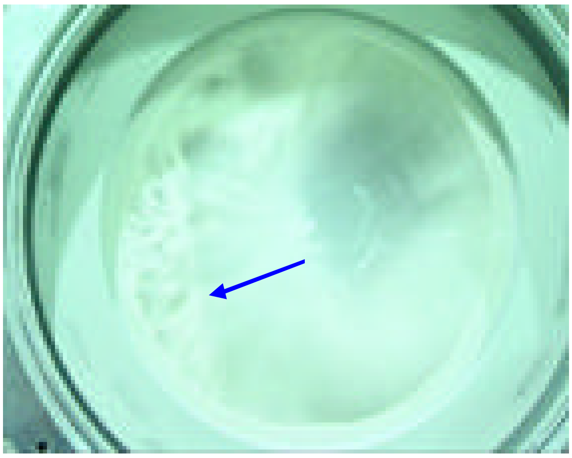
[Fig. 8a, b] The gas flows through the wet product ring, in the opposite direction to the centrifugal forces, from the outside to the inside. As this process is performed at a rather high speed, the product ring is constantly kept upright by the centrifugal forces in the filter drum. This guarantees that the product is loosened on the whole circumference of the drum, thus increasing its porosity and enabling its processing.



[Fig. 9] Counter impulse process - picture taken with high speed cameras at the Institute for MPE, University of Karlsruhe (TH)

Pictures taken with high speed cameras [Fig 9] show the propagation of the pressure wave in the chamber between the solid bowl and the filter drum. Within about 400 milliseconds, a gas flow passes through the filter cake in a direction opposite to the flow direction of the drying gas from the feed line, transferring a sudden pulse to the filter cake. For a short moment, finest particles are explosively lifted from the inner surface of the filter cake and shortly afterwards, they are pressed onto the cake ring through the centrifugal field of the centrifuge.

Additionally, in contrast with previous methods, the drying gas flows twice through the product cake: at first, when it is shot in, from the outside to the inside. As the gas must escape through the filter drum, it passes a second time through the filter cake, using the moisture transfer to the drying gas in a more efficient way.

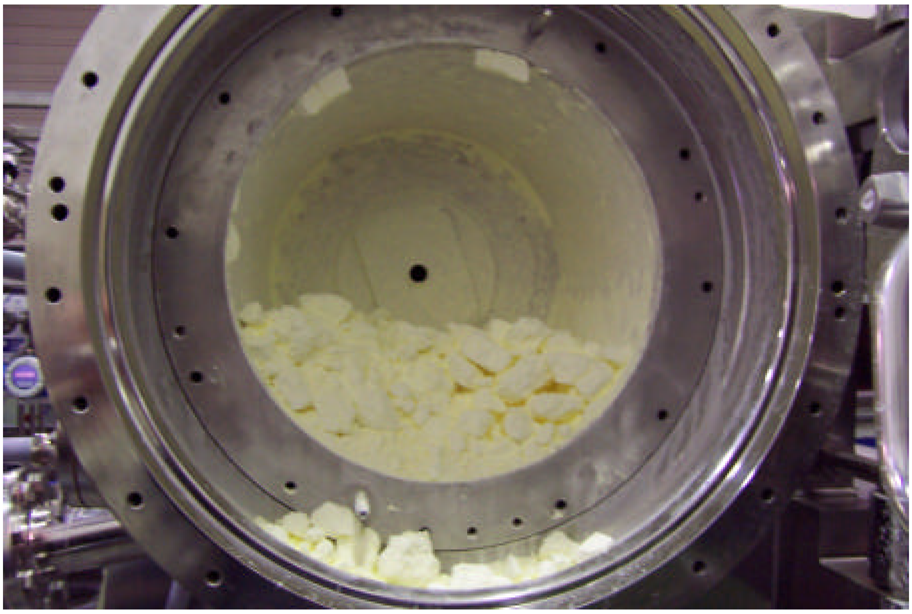


[Fig. 10a] Counter impulse method with dry product during the gas impulse.

[Fig. 10b] Counter impulse method with dry product shortly after the gas impulse – the cake remains

In order to reduce the drying time, drying gas may additionally be blown through the filling shaft into the filter drum. Contrary to the conventional fixed bed drying, the gas flows more uniformly through the filter cake thanks to the increased porosity.
In addition, as the product cake is constantly loosened, no drying cracks will be formed, thus preventing the additional gas from escaping through the filter drum without being used. The filter cake remains stationary [Fig. 10a, b] and will not roll in the filter drum as it is the case with the stop-and-go or the continuous drying; materials with a tendency to agglomerate [Fig. 11a, b] remain homogeneous and fluffy.

[Fig. 11a]
Product with tendency to agglomerate in case of conventional drying.



[Fig. 11b]
Agglomeration after fixed bed drying. The product is still wet within the lumps.

After this process, the dried product [Fig. 12a] will be discharged: For this purpose, the filter basket inside the still closed system is opened on the face and the powder is conveyed just by the rotation of the conical filter drum. A unit for gravimetric discharge, pneumatic or vacuum conveying is connected to this system.

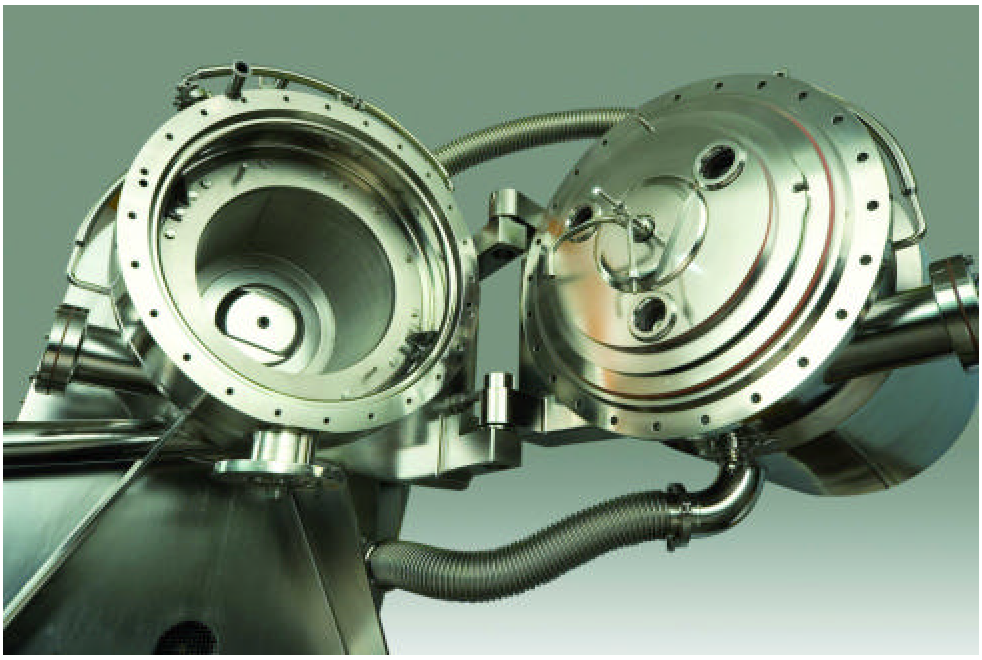
[Fig 12a]
Dry powder, homogenous and without agglomerates.

[Fig. 12b]
Dry powder, ready to be discharged with no residual heel cake. The counter pulse method avoids caking of the filter drum.

[Fig. 13]
Product discharge after conventional fluid bed drying with a product tending to agglomerate. The filter drum is covered with incrustations of the product.

The residual product in the filter is blown out through the shot nozzles. As the inner chamber of the centrifuge is free of any built-in parts, the system enables 100% product discharge without caking [Fig. 12b] – it can immediately be used for the next batch. Contrary to the conventional drying technology, the products tending to agglomerate do not only have product quality problems but are also problematic with respect to their discharge, and the filter drum has to be cleaned of incrustations before starting the next batch [Fig. 13].

To influence product quality during the process, the counter pulse procedure may optionally be controlled by PAT instruments, allowing, for example, on-line humidity measuring via NIR [Fig. 14].



[Fig. 14] Open suapension dryer, filter drum and seal plate

Until now, FSD suspension dryers by FIMA have mainly been used in the pharmaceutical and chemical industry for the production of APIs. Recently, however, we have seen increased interest from other industries such as the fine chemistry, mineral or color pigment industry. Depending on the application, systems are available for testing and production – the filling volumes range from 37 to 1600 liters of suspension, corresponding to a cake volume of 20 to 800 liters.

The FIMA project and process engineers give advice to customers on the planning of their system, on its integration into the existing production process, on the selection of control system and software as well as on the periphery configuration.