Candle Filtration by DrM, Dr. Müller AG

Stable Process Conditions due to Regeneratable Filter Candles

Speaker: Dr.-Ing. Patrick Morsch

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Date: 8th November 2023

DrM

Content

1. Introduction – Particle separation

Mastering the particle size in the process stream

→ Removal of particles or enrichment of the particle concentration as a process objective.

Why?

For stabilising process control (downstream processing) and obtaining pure process streams (solid/liquid) for product formulation/process intensification.

How?

There are 2 groups of separators available:

- Physical separators:

Like centrifugal separators, they work by gravity, inertia and centrifugal force.

Lower separation efficiency for particularly fine particles.

- Geometric separators:

Mesh / Pore size gives a clearly defined particle size and thus a separation limit.

Highest separation efficiency with different complex designs.

Depending on the particle size to be separated.

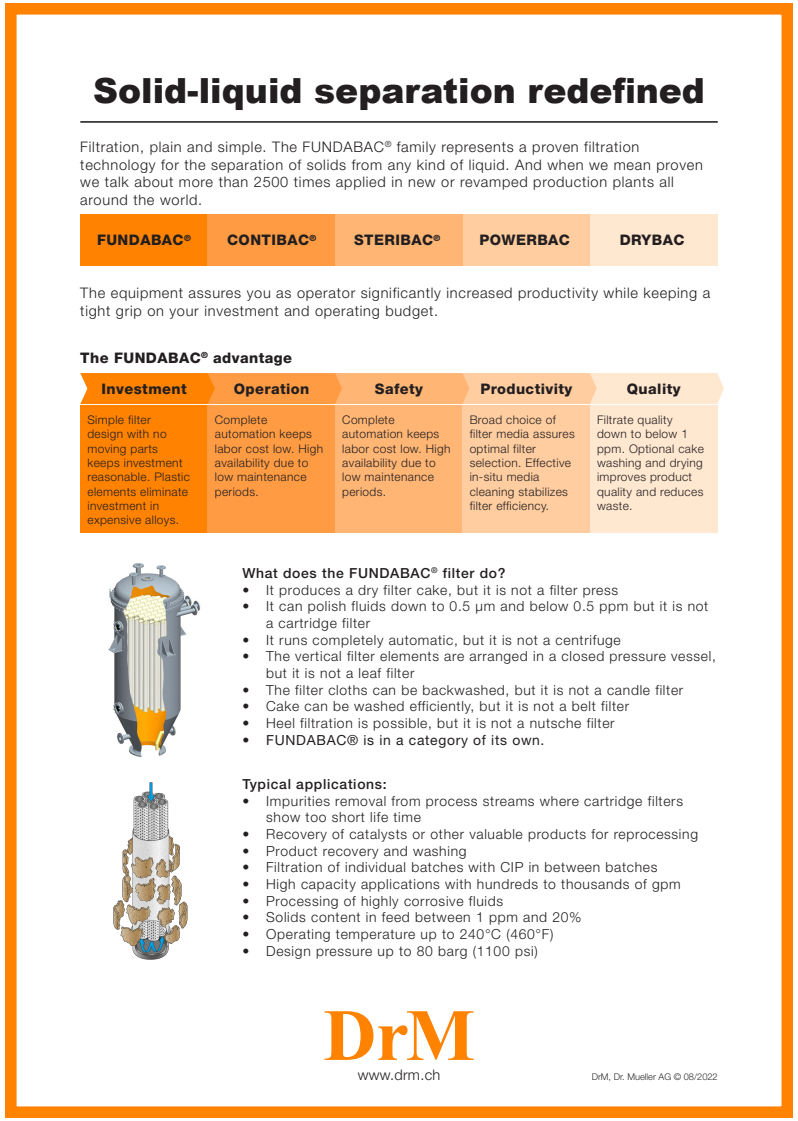
→ Combinations of both types of separator are possible in one process flow diagram.

Examples

- Safety filters of e.g. hydrocyclones, disc separators and other physical separation methods

(Fractional separation efficiency of e.g. cyclones for finest particles poor; for filter media for smallest particles very high (over 99%))

- Cleaning: water, lubricants, beverages, chemicals...
- Recovery: catalyst/process water recycling for cost reduction (e.g. tailing process water)



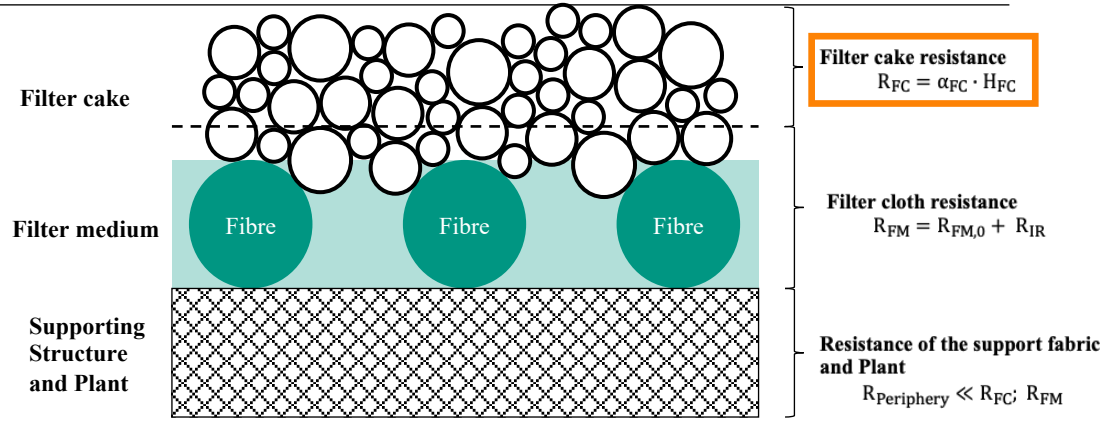
1. Theory – Different separation techniques

Geometric Separation

Cake filtration:

- For particles < 1 µm, the pressure drop Δp of the filter cake increases sharply $\Delta p \propto x^{-2}$ (Carman Kozeny).
- Purities < 1 ppm possible
- Solids concentrations up to 20 w/w-%

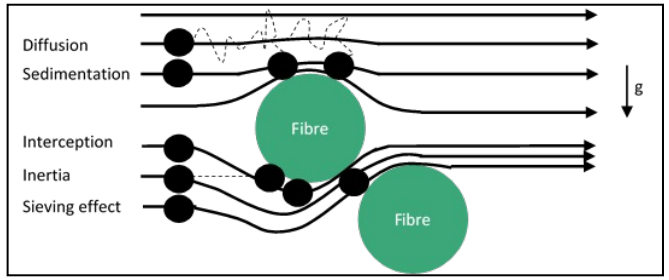
→ Regeneration possbile



Depth filtration:

- Separation in the submicro range possible
- High concentrations cause the depth filter to clog quickly.
- Flow rate decreases sharply → standard/clogging filtration

→ Regeneration difficult



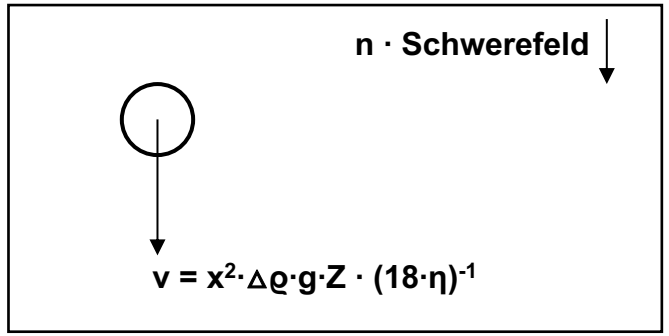
Physical Separation

Sedimentation:

Earth / Centifugal field generates separating force

Energy required to accelerate the mass

Lower degree of separation than geometric separators



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1. Theory – Filtration for particle separation

- Particle concentration in the suspension up to 20 w/w-%.
(Higher possible; depends on feed stream)

- Particle size x > approx. 0.5 µm (For cake filtration)

- Filtration until a pressure loss/ or volume flow limit is reached
(successive clogging of the free area)

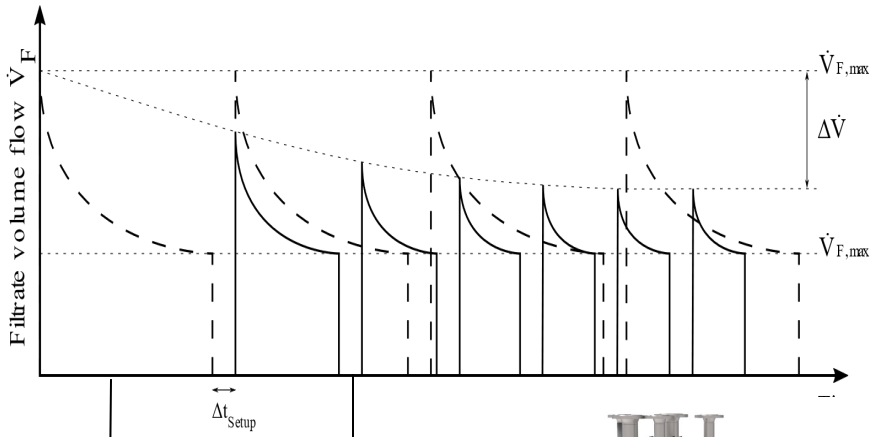
- Regeneration by backwashing, brushing, nozzles...

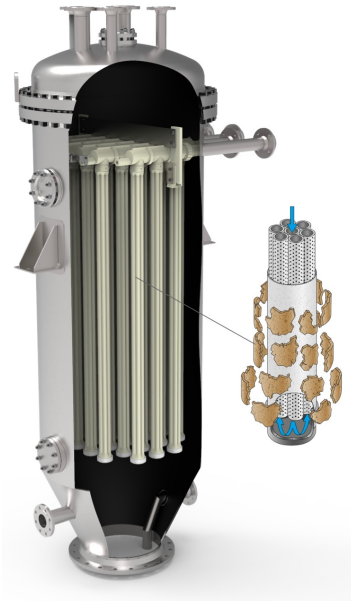
- Driving potential: pressure gradient through pump/pressure gas

Process engineering objective

- **Obtaining a dry filter cake → Production (FUNDABAC®)**
- **Retention of oversize particles → Safety filter**
- **Separation of all particles → Polishing filter**
- **Concentration of slurry → Thickener (CONTIBAC®)**
- **GMP & FDA applications → Sterile filter (STERIBAC®)**

? How does the separation take place with such a filter ?





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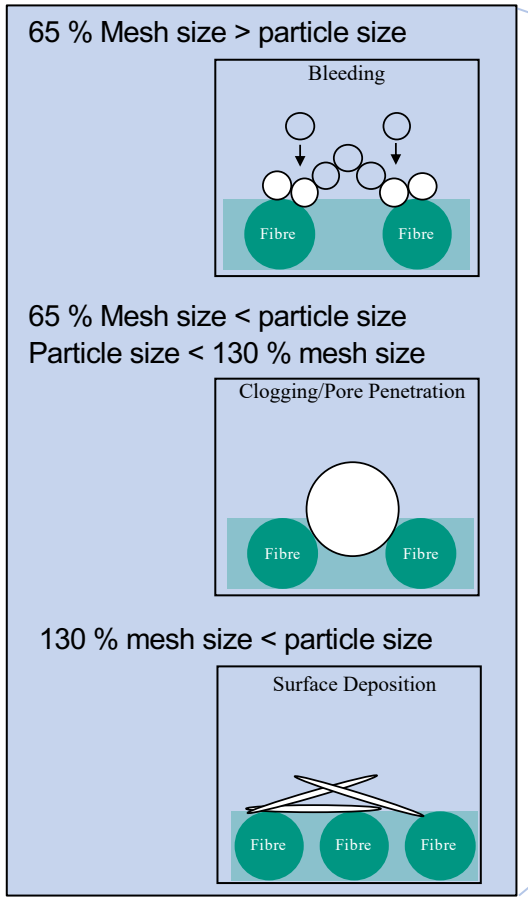
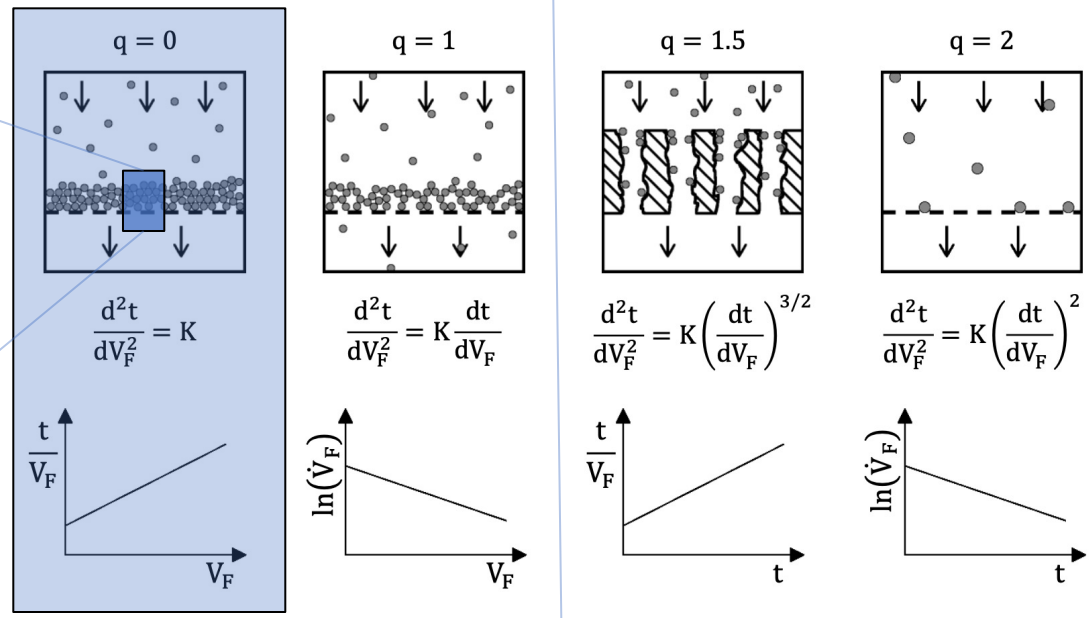
Filter equation analogous to the sliding equation of

→ **Hermans und Bredée**

$$\frac{d^2t}{dV_F^2} = K \cdot \left(\frac{dt}{dV_F}\right)^q$$

q = 2: clogging filtration
q = 1: Intermediate filtration
q = 1.5: standard/depth filtration
q = 0: cake filtration





+ High flow rate, long service life and low maintance required
- Turbidity shock must be handled

+ Fine Seperation without filteraid
- Strong Clogging, Short service life

2. Theory - Cleaning / Cleaning Mechanisms

I. Cake discharge

- Distinction between discharge in gas phase (FUNDABAC®) or liquid phase (CONTIBAC®)
- Dependent on particle system, type of fabric, process mode

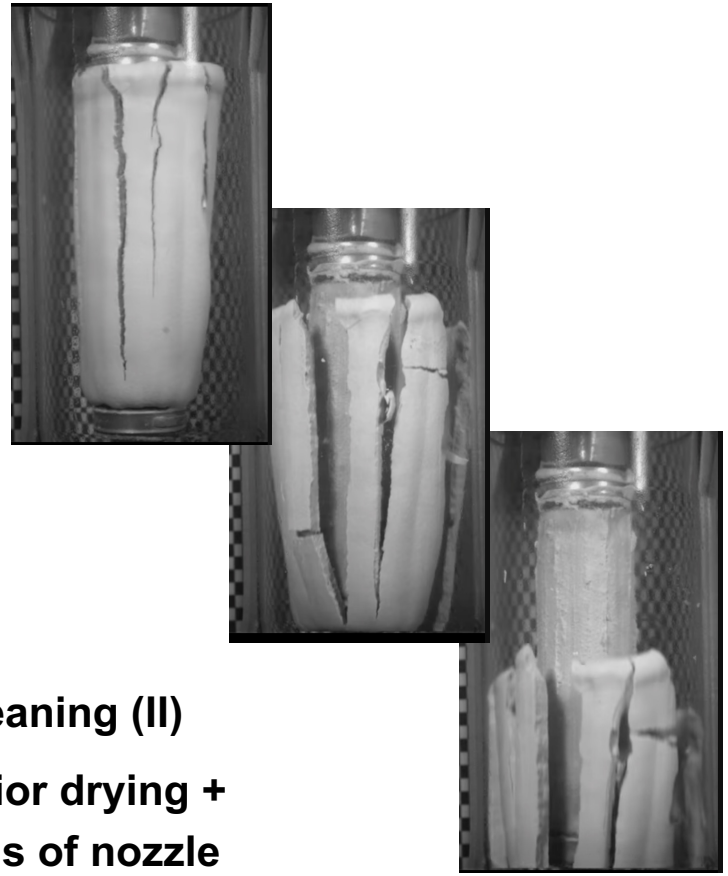
Thesis aims at cake discharge for fabrics with mesh sizes < 25 µm. Elaboration of 2 models for monofilament fabrics (single fibres) and multifilament fabrics (fibre bundles).
Total resistance and type of mesh occupancy of particular interest

P.Morsch (2021) - Detachment of fine-grained thin particle layers from filter media

II. Intra-cloth cleaning

- Detachment of remaining soluble and insoluble particles from the tissue fibres

https://www.youtube.com/shorts/6U2pA39lcRE



<u>Discharge in liquid phase:</u>
CONTIBAC®
cake discharge (I) at low pressure + Downstream pulsation flow for intra-cloth cleaning (II)

<u>Discharge in gas phase:</u>
FUNDABAC®
Cake discharge (I) at higher pressure with prior drying + Subsequent intra-fabric cleaning (II) by means of nozzle

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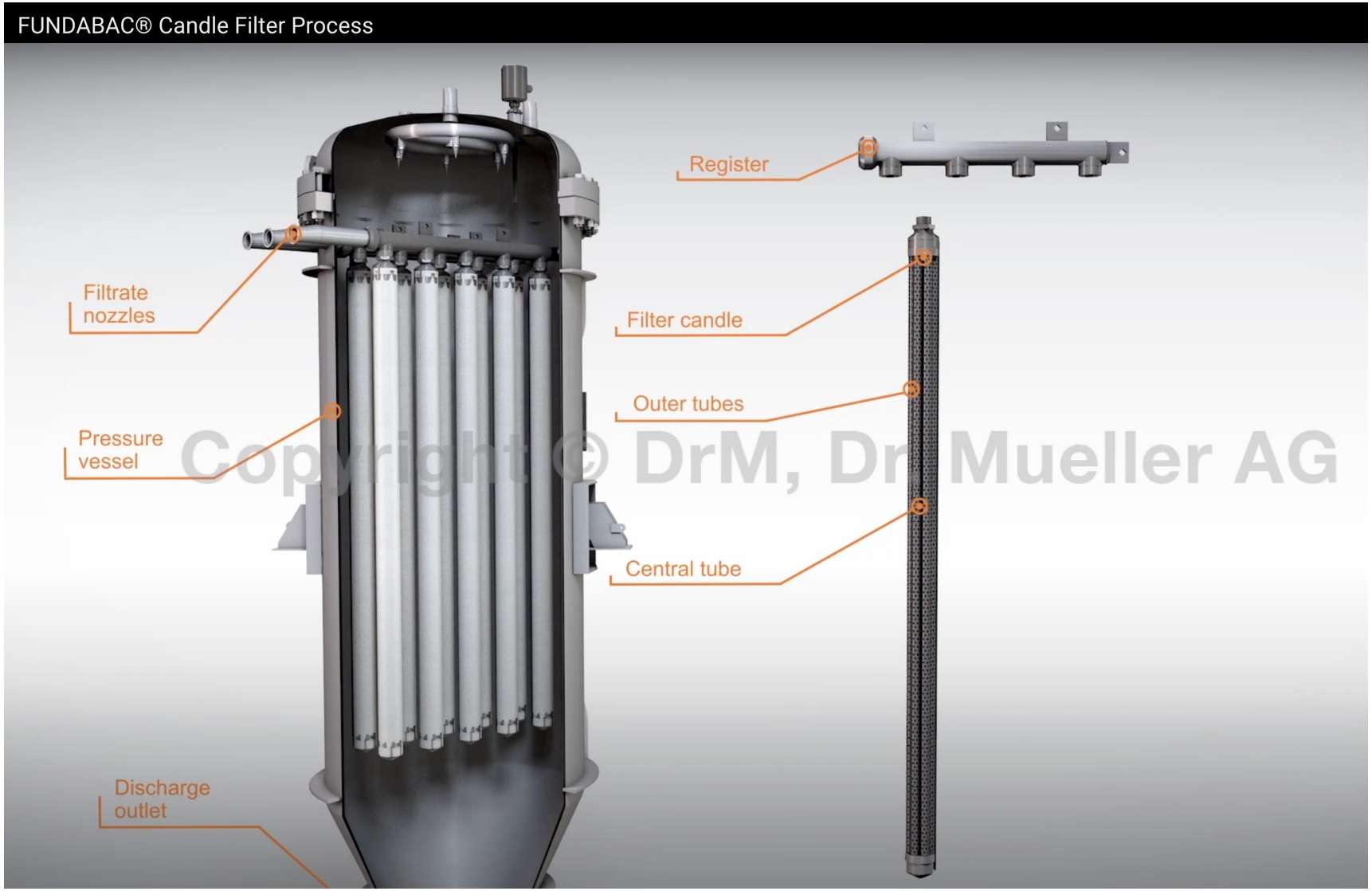
1. Introduction – DrM - Video

https://www.youtube.com/watch?v=QiPID6Yp6To



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3. Technical Details – Scale-Up

From laboratory to industrial scale - scale-up strategy through numbering-up.

Nutsche Filter

Pressurized Filter Cell
0.001 m^2
→ Information about specific flow rate and drying/washing

TSD Filter

Total Scale Down

Laboratory Candle Filter
0.012 m^2
→ Information about specific flow rate, drying/washing and cake discharge

Pilot Filter

Mono-/Multi-Candle

Small/Semi Industrial Candle Filter
With 1 to 6 candles
0.16 – 3.0 m^2
→ Numbering up from the few candles to the real industrial size

Pilot Filter

Full-Skid

Filter Vessel

Industrial Filter with up to hundreds of candles with max. 2500/3850 mm length each (standard / special design)

Semi-Skid

Lab Size → Pilot Size → Size → Industrial

Introduction | Theory | Technical Details | Appendix

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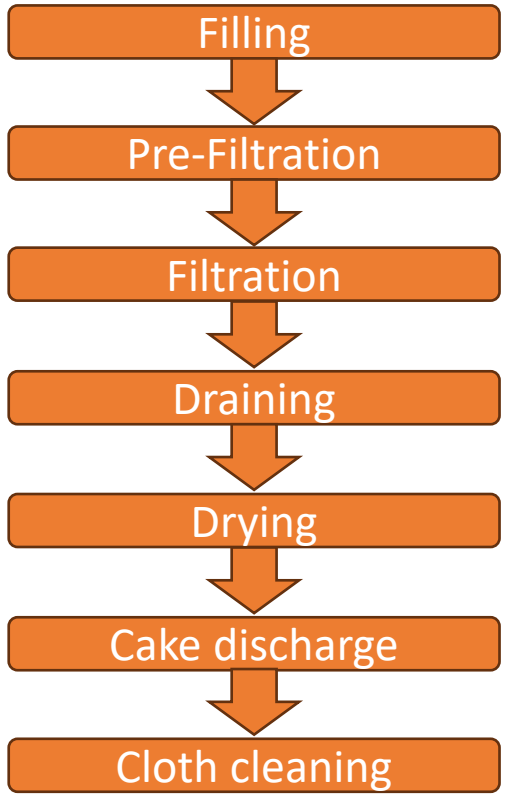
3. Filter with periodic cleaning - FUNDABAC® principle

Candle filter for dry cake discharge



FUNDABAC® / CONTIBAC® Candle Filter

1. **Top connections: overflow, heel-volume inlet, nozzle cleaning, instruments, Vent, etc.**
2. **Filtrate outlets (Register**
3. **Header**
4. **Manifold**
5. **Bottom connection: inlet, heel-colume outlet**
6. **Cake discharge valve**

- **<u>Applications :</u>**

Adipic acid production

(Bio-)diesel purification

Treatment of lubricating oil

Process water treatment

Waste water treatment

Vaccine production

Zeolite production

Production of rubber additives

And many more…

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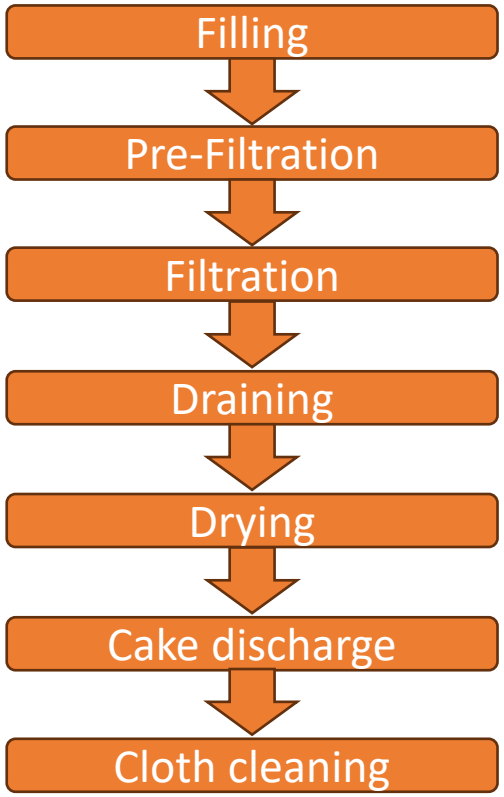
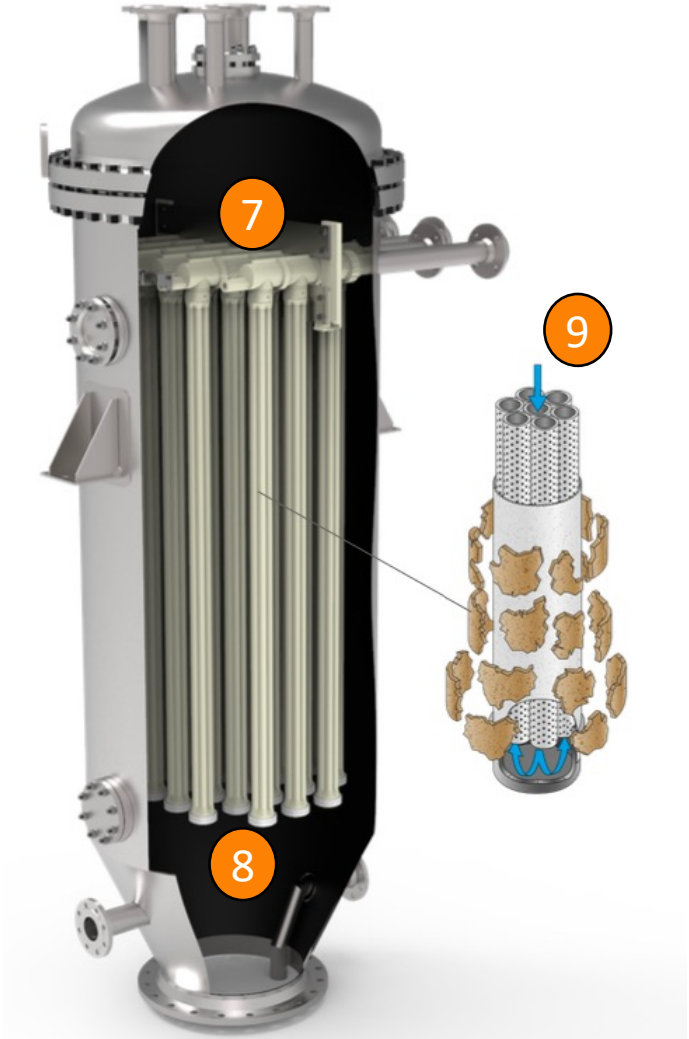
3. Filter with periodic cleaning - FUNDABAC® principle

DrM

Candle filter for dry cake discharge





FUNDABAC® / CONTIBAC® Candle Filter

1. **Top connections: overflow, heel-volume inlet, nozzle cleaning, instruments, Vent, etc.**
2. **Filtrate outlets (Register**
3. **Header**
4. **Manifold**
5. **Bottom connection: inlet, heel-colume outlet**
6. **Cake discharge valve**
7. **Register**
8. **Candle Filter**
9. **Illustrated cake discharge**

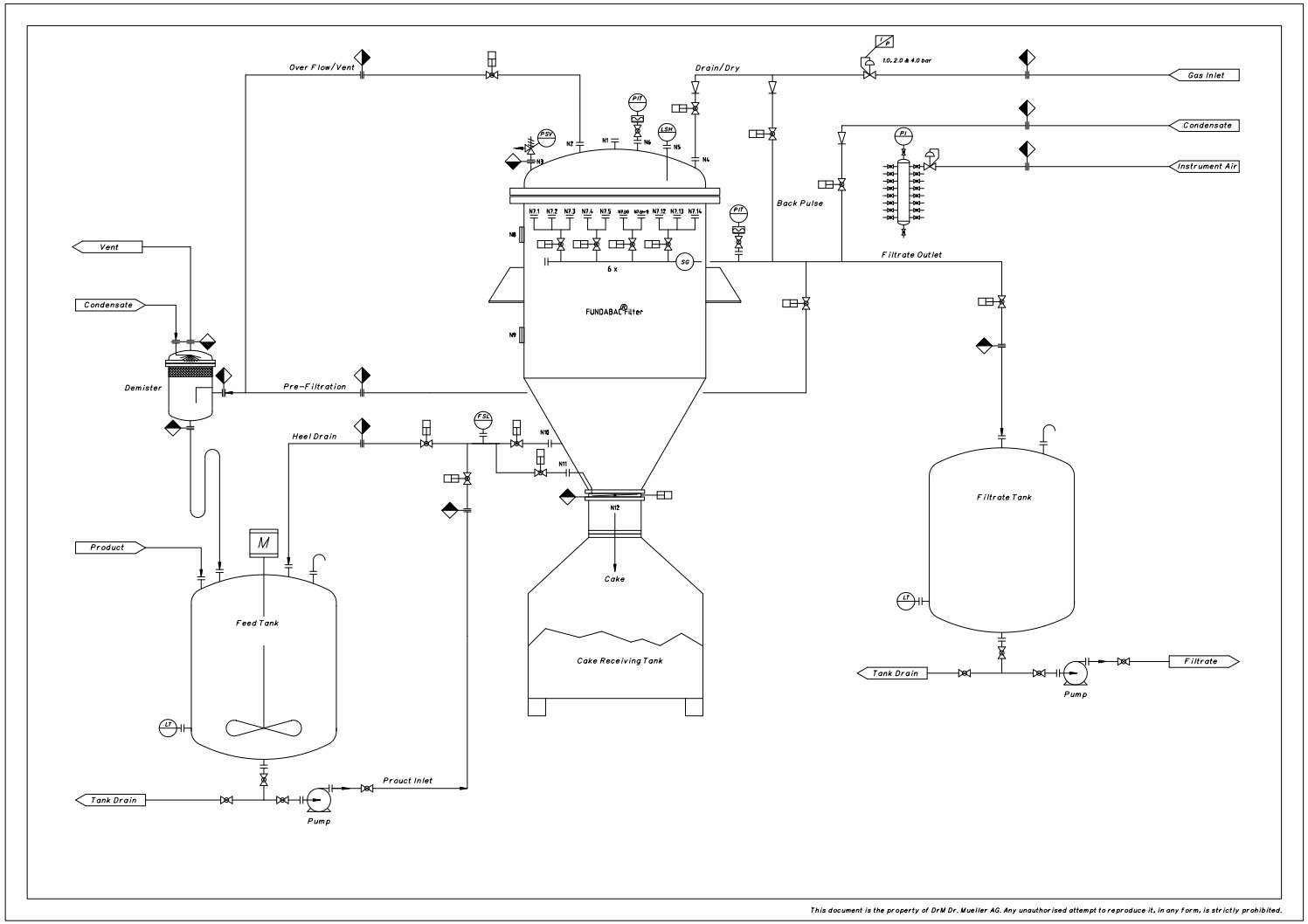
Semi-Skid

Full-Skid

3. Filter with periodic cleaning – FUNDABAC® principle

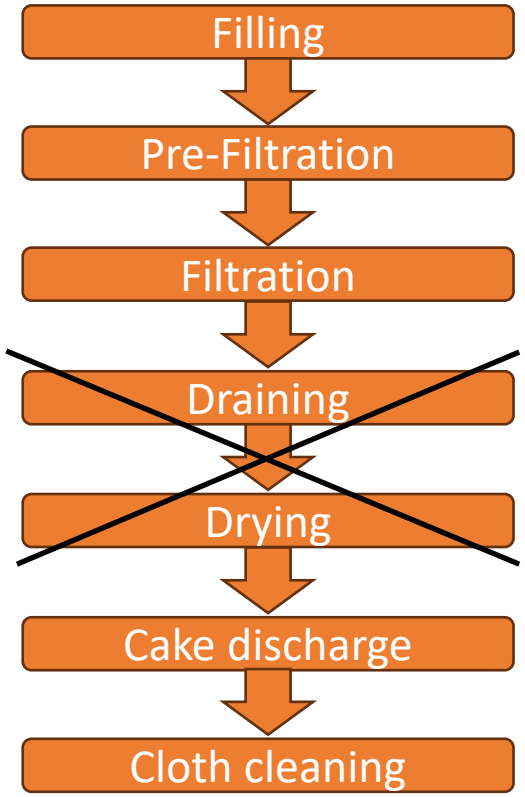
Candle filter for dry cake discharge

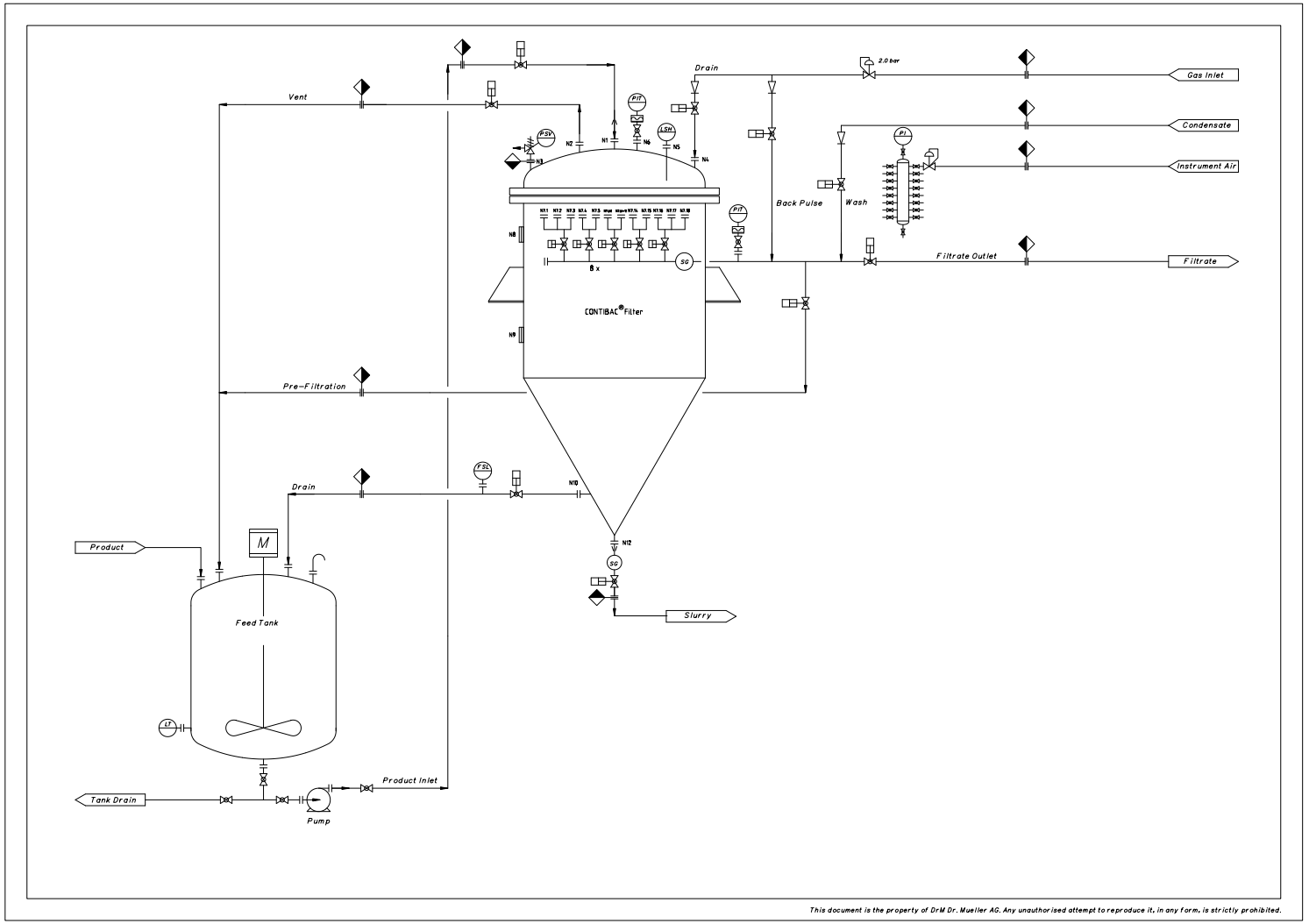
- Filling
- Pre-Filtration
- Filtration
- Draining
- Drying
- Cake discharge
- Cloth cleaning



3. Filter with periodic cleaning – CONTIBAC® principle

Candle filter for dry cake discharge





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3.Filter with periodic cleaning - Application

Specialty and fine chemicals manufacturing

- Additives
- Adhesives
- Coatings
- Cosmetics
- Decolorization
- Dyestuffs
- Flavors & Fragrances
- Pigments
- Plasticizers
- Plasticizers
- Polymers
- Resins
- Rubber vulcanizer

Food and Agrochemicals

- Catalyst recovery
- Crop protection chemicals
- Fatty Acids
- Lactose syrup
- Sugars
- Sweeteners
- Vegetable oil

Mineral and metal processing

- Aluminum recycling
- Bauxite and Alumina filtration
- Catalyst production
- Leaching
- Lithium
- Nickel production
- Non-ferrous metals
- Potassium Nitrate
- Rare Earth
- Steel
- Titanium Dioxide
- Zeolites

Environmental

- Biodiesel impurity removal
- Carbon Capture & Storage (CCS)
- Flue Gas Desulphurization (FGD)
- Incineration waste gas treatment
- Quench water
- Recycling
- Solar cell production
- Wastewater

Bulk Chemical and Petrochemical

- Adipic Acid thickening
- Aniline recovery
- Aromatics and resins
- Butane Diol catalyst recovery
- Precious metal catalyst recovery
- Chlor Alkali
- Glycol production
- High purity epoxy production
- Removal of Hypochlorites
- Lubricant wax removal
- Olefins byproduct filtration
- Catalyst removal in oil additives
- Polyols salt removal
- Impurities removal in PPS production
- Purified Terephthalic Acid recovery
- Rubber chemicals catalyst recovery
- Synthesis Gas
- Toluene Diamine preparation and recovery

Oil and Gas Processing

- Mercury removal from crude oil
- FCC Catalyst fines
- Gas Sweetening
- MEG Regeneration
- Pigging Water treatment
- Produced Water filtration
- Sulfur recovery

Electronics

- Copper foil production
- Graphite Oxide (GO)
- High Purity Alumina (HPA)
- LCD production
- Lithium battery production
- Lighting
- Silane
- Photoresist
- Silicon ingot and wafer slicing
- Silicon wafer shaping

Pharma and Nutraceuticals

- Active Pharmaceutical Ingredients
- Antibiotics
- Catalyst recovery
- Cell harvesting
- Decolorization
- Decolorization
- Vitamins
- X-Ray contrast agents

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3. Contacts

- Sales Responsible for Filter in UK
- FUNDAMIX® - Vibro Mixer
- FUNDAWAVE® - Vibro Crossflowfilter

Dr.-Ing. Patrick Morsch
Product & Sales Manager

DrM
Sophisticated flexible filtration and mixing solutions
FUNDABAC® | FUNDAMIX® | Single-Use Technologies

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- Sales Responsible for Filter in France, Belgium

Corentin Boulland
Product Manager Sales

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4. Appendix

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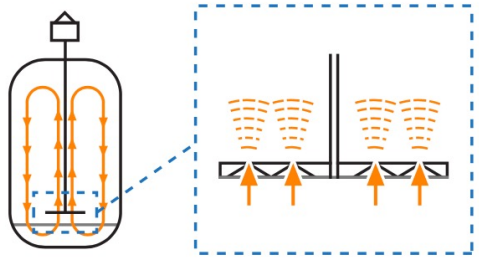
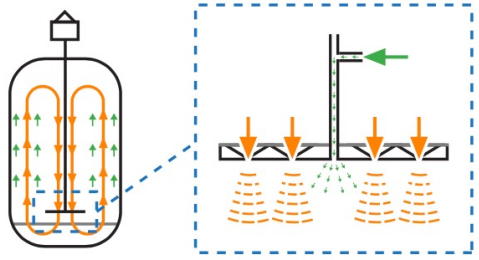
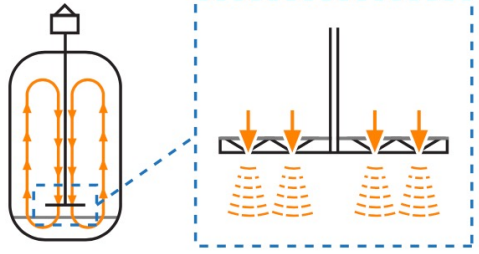
FUNDAMIX® - Function Principles of Vibro-Mixing



Mixing plate Type A
Type A with the conical bores facing upwards is the preferred standard. Type A has higher efficiency due to upward flow through the whole vessel. The plate can be mounted very low, so the mixable heel volume is reduced to a minimum.



Mixing plate Type B with gas dispersion
If gas is required then it can be injected through the shaft with mixer plate type B. The liquid flows downwards distributing the fine gas bubbles in the vessel generating an excellent gas dispersion. Another well proven set up is to inject the gas between two plates to break the bubbles.



Mixing plate Type B
Mixer type B with the conical bores facing downwards is chosen if the product tends to sediment, creates foaming or if no air is to be introduced during mixing. The distance to the bottom of the vessel is about the diameter of the plate.

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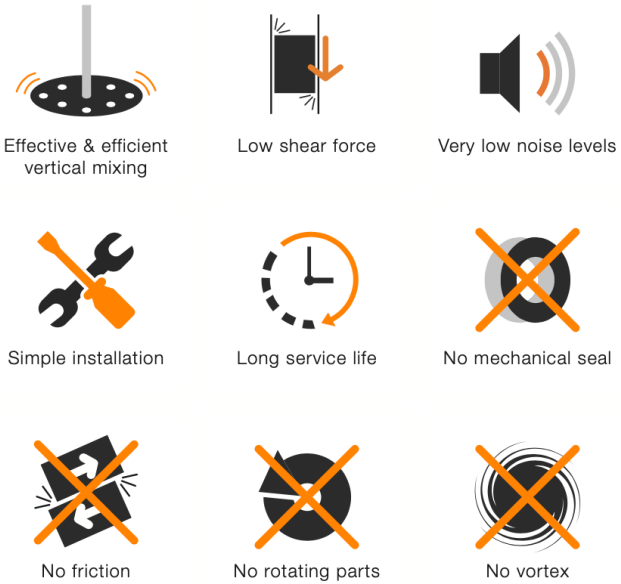
FUNDAMIX® - Assembly

Key Advantages



- Reduced residual liquid volume due to low positioning of the plate
- Perfectly suitable for CIP/SIP
- High degree of containment suitable for pathogens and demanding applications
- No baffles required
- No lubricants required
- No damaging of life cells
- Low installation & maintenance cost
- Low energy consumption

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FUNDAMIX®

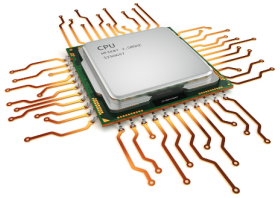
Applications and industries

Chemical

- suspending of solids such as filter aid
- Fluidization of solids
- Dissolution of flavors and fragrances
- Catalysts, activated carbon or bentonite in liquids
- Precipitation or crystallization of solids during neutralization
- Gas/liquid batch reactions like hydrogenations and chlorinations

Agroscience

- Algae cultivation
- Animal health products
- Seed preparation



Electronics

- Preparation of solvents
- Dissolution of Copper with Sulfuric acid under high temperatures
- Plasma coating of fluorescent materials in fluidized bed reactor (CVD process)
- Mixing of anode materials in Lithium battery production
- LED production

Food & Beverage

- Mixing of soft drinks
- Blending alcoholic beverages
- Agitation of milk
- Beer ingredients preparation
- CO2 saturation
- Addition of flavors, salt, sugar, vitamins and dyestuff

Pharmaceutical and cosmetics

- Insulin production
- Blood fractionation
- Preparation of sterile solutions
- Oil emulsification
- Cannabis extraction
- Homeopatics activation processes
- Mixing of injectable suspensions in sterile vessels for filling of vials

Microbiological and Biochemical

- Anaerobic/aerobic fermentations
- Submerse culture of mammalian cells
- Protein solutions
- Human tetanus and plant cells trypsinization
- Vaccines production
- Tetanus production

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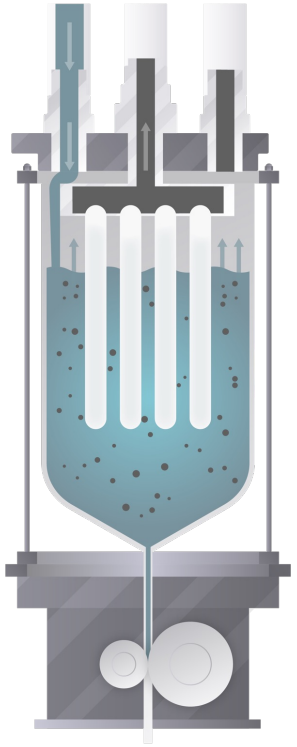
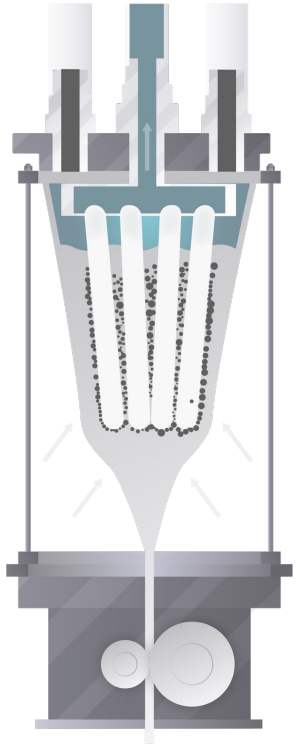
Single-Use Technology – FUNDALOOP®: Cyclical Cake Filter

Step 1: Filtration



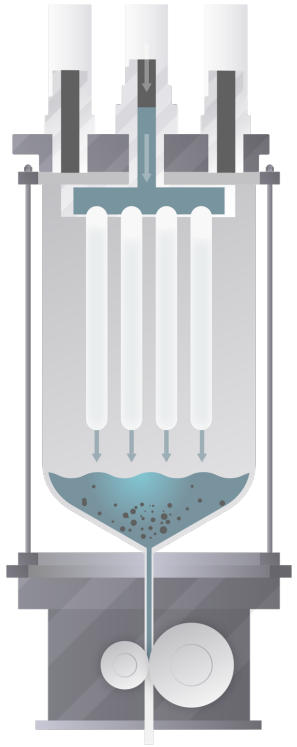
- Filling with **cell suspension**, subsequent **filtration**

Step 2: Heel Volume



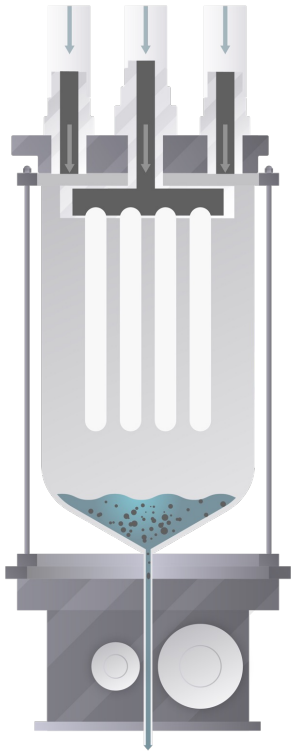
- Squeezing of bag with **compressed air**, heel volume filtration

Step 3: Back-Flush



- Filter cake **washed** down

Step 4: Discharge



- Biomass **discharged**, filter ready for next filling

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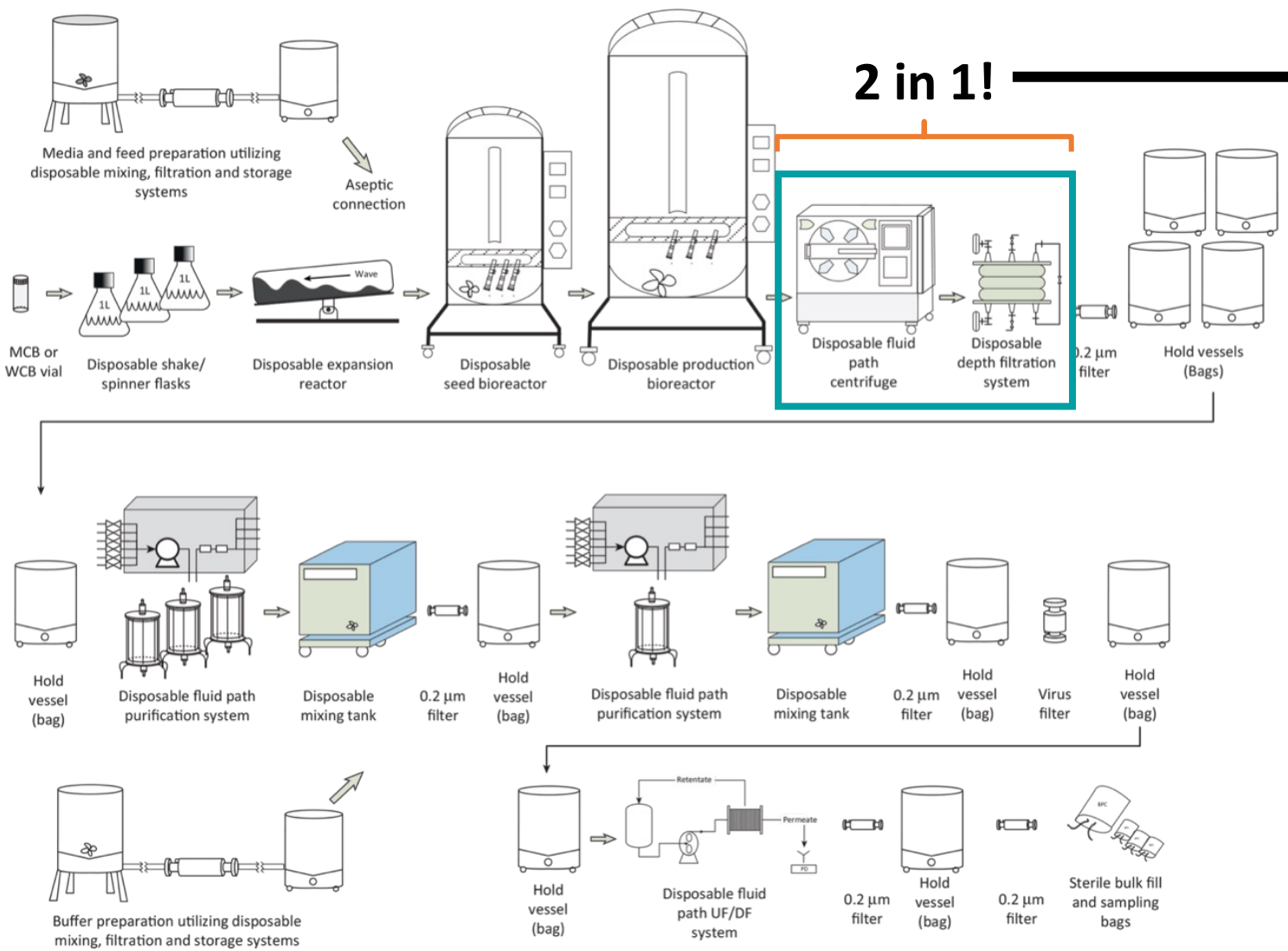
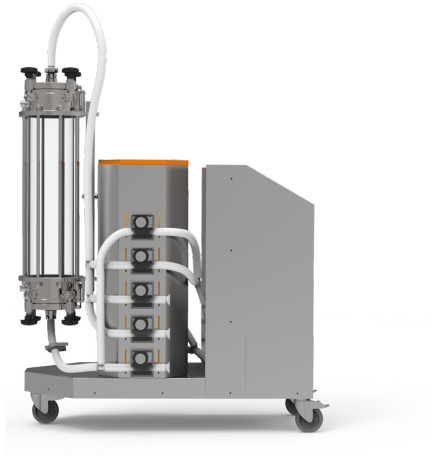
Biopharmaceutical Cell Harvest





The FUNDALOOP® combines both primary and secondary filtration in one technology

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