3 MECHANICAL PROCESS ENGINEERING

INTRODUCTION

SEPARATION METHODS: CLASSIFYING AND SORTING

SEPARATION METHODS: SEPARATION IN A GRAVITY FIELD

SEPARATION METHODS: SEPARATION IN A CENTRIFUGAL FORCE FIELD

SEPARATION METHODS: FILTRATION

COMMINUTION

Learning unit operations of mechanical process engineering by experimentation

GUNT offers a complete range of units to learn the unit operations involved in mechanical process engineering.

Please note:
Your laboratory facilities must be suitable for operation of the units. Depending on the specific process and the materials used, sealed floors, drains, water and /or compressed air connections, ventilators, special foundations, secure material storage facilities etc. may be required.

To evaluate many of the experiments you will need professional analysis systems beyond the scope of the training system packages supplied by GUNT.

Please contact us. We will be happy to give advise.

MIXING AND AGGLOMERATION

STORAGE AND FLOW OF BULK SOLIDS

FLUIDISED BEDS AND PNEUMATIC TRANSPORT

Visit our website www.gunt.de

THE GUNT LEARNING CONCEPTS OF MECHANICAL PROCESS ENGINEERING

What does mechanical process engineering involve?

Process engineering is the engineering science of material transformation.

Mechanical process engineering involves the changes in material properties (e.g. particle size), and composition (concentration), due to mechanical effects.

The mechanical effects are forces acting on the materials. These forces may include compression forces, friction forces, impulses, or forces triggered by flow resistances.

The material systems with which mechanical process engineering concerns itself are termed dispersed systems. They consist at least of a dispersed phase and a continuous phase. The dispersed phase usually comprises large numbers of individual particles which are finely distributed (dispersed) in the continuous phase. The dispersed phase largely involves solids, however, both phases may also be liquid or gaseous. Examples of dispersed systems are bulk solids such as sand, ore-bearing rock, suspensions, emulsions and dusts.

How can the unit operations in mechanical process engineering be classified?

Unit operations in mechanical process engineering

INVOLVING CHANGE IN PARTICLE SIZE	WITHOUT CHANGE IN PARTICLE SIZE	
Comminution	**Separation Methods**	**Mixing**
Agglomeration	**Storage and Flow of Bulk Solids**	**Fluidised Beds and Pneumatic Transport**

The processes can essentially be divided into two principal categories. In the comminution and agglomeration (particle size enlargement) processes, the size of solid particles is purposely altered. In the separation, mixing, storage and transport of bulk solids, the particle size usually remains unchanged. The separation methods in many cases involve the separation of solid, dispersed phases from fluids and the division of solid compounds into fractions with different particle properties.

In fluidised beds, mixing, separation or agglomeration processes may occur, depending on the application.

Prof. Dr. Wolfgang Gorzitzke (Anhalt University of Applied Sciences), our technical advisor on mechanical process engineering

Prof. Gorzitzke advised us when we were setting up this range and contributed his many years of experience in the area of mechanical process engineering.

The unit operations…			…and the appropriate GUNT unit
Comminution		▶	**CE 245** ***Ball Mill***
Agglomeration		▶	**CE 255** ***Rolling Agglomeration***
SEPARATION METHODS	**Classifying**	▶	**CE 275** ***Gas Flow Classification***
		▶	**CE 264** ***Screening Machine***
	Sorting	▶	**CE 280** ***Magnetic Separation***
	Separation in a Gravity Field	▶	**CE 115** ***Fundamentals of Sedimentation***
		▶	**HM 142** ***Separation in Sedimentation Tanks***
		▶	**CE 587** ***Dissolved Air Flotation***
	Separation in a Centrifugal Force Field	▶	**CE 282** ***Disc Centrifuge***
		▶	**CE 235** ***Gas Cyclone***
		▶	**CE 225** ***Hydrocyclone***
	Filtration	▶	**CE 116** ***Cake and Depth Filtration***
		▶	**CE 117** ***Flow through Particle Layers***
		▶	**CE 287** ***Plate and Frame Filter Press***
		▶	**CE 283** ***Drum Cell Filter***
		▶	**CE 284** ***Nutsche Vacuum Filter***
		▶	**CE 286** ***Nutsche Pressure Filter***
		▶	**CE 579** ***Depth Filtration***
Mixing		▶	**CE 320** ***Stirring***
Storage and Flow of Bulk Solids		▶	**CE 210** ***Flow of Bulk Solids from Silos***
		▶	**CE 200** ***Flow Properties of Bulk Solids***
Fluidised Beds and Pneumatic Transport		▶	**CE 220** ***Fluidised Bed Formation***
		▶	**CE 250** ***Pneumatic Transport***

BASIC KNOWLEDGE

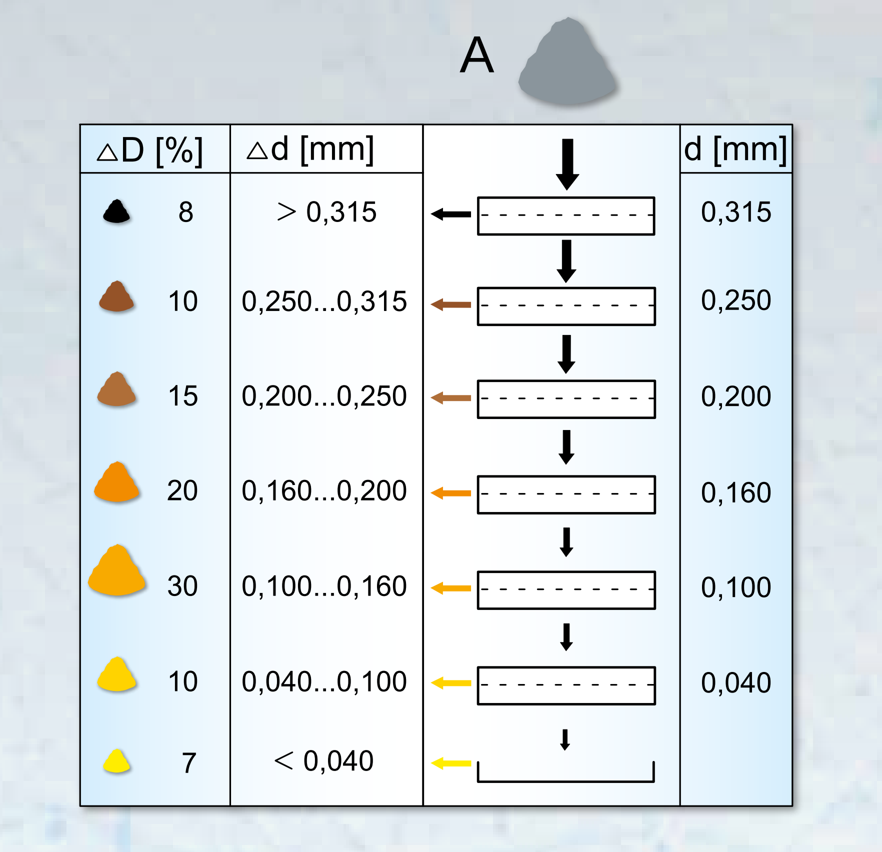
CLASSIFYING

Classification is a mechanical separation method for solid compounds. It utilises either, the geometric features (size) or the settling velocities of the individual particles for the separation process. Accordingly, a distinction is made between sieve and flow classification.

Ideally, a classifier separates a feed with differing particle sizes into coarse and fine materials. The coarse material would then contain all the particles larger than a specific separation size, and the fine material all the particles smaller than that size.

The simplest example of a classifier is a sieve. In this case the separation size is determined by the sieve mesh width. With the sieve layout shown, it is possible to sort a feed into several particle size classes.

A practical example of the application of such a layout (though with larger sieve mesh widths) is the separation of ballast, gravel and sand from quarried material.



△D [%]	△d [mm]	d [mm]
8	> 0,315	0,315
10	0,250...0,315	0,250
15	0,200...0,250	0,200
20	0,160...0,200	0,160
30	0,100...0,160	0,100
10	0,040...0,100	0,040
7	< 0,040	

*Classification of a feed **(A)** by sieving:*
***d** sieve mesh width, **Δd** particle size interval*
***ΔD** proportion of particle size interval referred to feed*

In **sieving,** each particle is compared to a sieve mesh according to its size and shape. Irregularly shaped particles may be hindered in passing through the sieve mesh depending on their positioning or orientation. The particles may also obstruct each other, or adhere to each other. It is therefore necessary to provide each particle with the opportunity to pass through the mesh multiple times. This can be accomplished, for example, by vibrating, tumbling, projectile or horizontal movements of the sieves.

Flow classification may take place in gases (air) or liquids (water).

In *wet flow classification,* the differing settling velocities of particles in a liquid flow are used as a separating criterion. The settling velocity depends on the size, density and shape of the individual particles and the resultant forces due to flow resistance and weight.

In *gas flow classification (wind sifting),* an airflow is used for classification instead of a liquid. The underlying laws of the separation principle applying to this separation are identical to those of wet flow classification. Wind sifters are used, for example, in the cleaning of corn, to separate off toxic components such as secale cornutum (ergot).

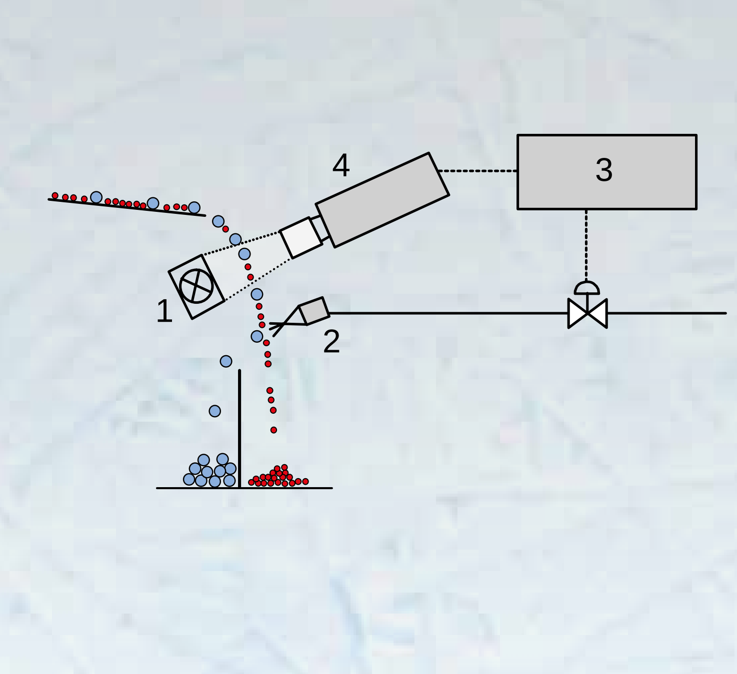
BASIC KNOWLEDGE

SORTING

Sorting is a mechanical separation process in which a solid compound containing different material characteristics is divided into fractions with the same material characteristics. In sorting, properties such as density, colour, shape, wettability or magnetisability are utilised.

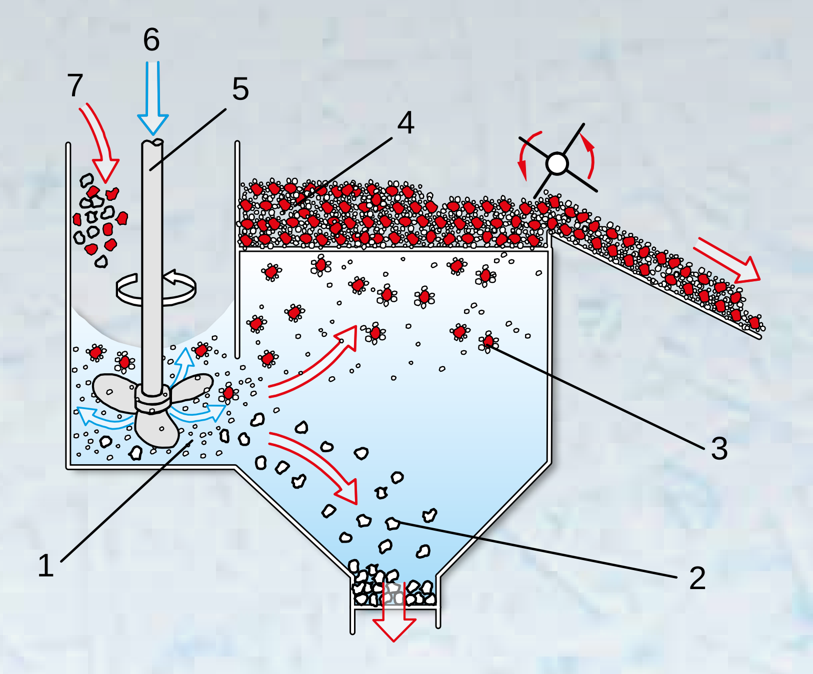
- Where *density* is applied as the separation criterion, a **float-sink sort** is suitable. A solid compound is placed in a liquid. The particles in the compound which are of lower density than the liquid float on the surface, while higher-density particles sink. One application of this is in coal preparation, in which the coal is separated from the surrounding strata.

- In **magnetic separation,** a solid compound is separated into its constituent components based on the *magnetic* properties of those components. Magnetic separators are used, for example, in coal and ore preparation.



Fundamental principle of an optical sorting process:
***1** light source, **2** compressed air jet*
***3** image analyser with controller*
***4** camera*

- The *shape and colour* of specific particles can be recorded from a solid compound using high-resolution cameras. Using a special electronic analysis technique, the detected particles can be separated out of the compound by an airflow. **Optical sorting methods** are used in the recycling of glass.



Fundamental principle of flotation:
***1** air bubbles, **2** wettable particles*
***3** non-wettable particles, **4** foam*
***5** stirrer with hollow shaft, **6** air, **7** solid compound*

- The *wettability* of specific materials with water in **flotation,** sorts fine-grained solids. The solid compound to be separated is placed in a container with water. Air bubbles are introduced into the water. The bubbles adhere to the solid particles which are not easily wettable with water. Those particles are carried with the bubbles to the surface of the water, where they form a solid-bearing foam which can be scooped off. No bubbles adhere to the water-wettable particles. They remain in suspension or sink to the bottom. Flotation is the most frequently applied method of sorting particles < 0.5 mm.

CE 275 Gas Flow Classification

*** Gas flow classification with a zigzag sifter**

*** Transparent duct to observe the separation process**

*** Practical experiments on a laboratory scale**

Technical Description

Zigzag sifters permit classification of solid compounds. The solid compound being separated is charged into the feed hopper. The compound is fed into the zigzag duct of the sifter at mid-height by way of a vibrating trough. An air flow flows upwards through the vertical duct. Depending on the geometry and density of the particles, they are carried along by the air or drop down due to gravity. At every bend in the duct the solid compound passes through the air flow and falls onto the opposite wall of the sifter. This corresponds to one sifting stage. Owing to the flow conditions, a vortex wake is formed between two bends of the zigzag duct. It ensures that the solid matter moves roughly perpendicular to the air flow. In this way, a transverse sift takes place at every bend. Sequencing of large numbers of such stages result in very fine separation. CE 275 features a 20-stage zigzag duct. Transparent material provides optimum observation of the processes in the duct.

A fan generates the air flow. The volumetric air flow rate and the solid mass flow are adjustable. The fine material transported upwards with the air flow is separated by a cyclone. Pressure measurement points at the relevant positions in the trainer enable the pressure loss to be determined.

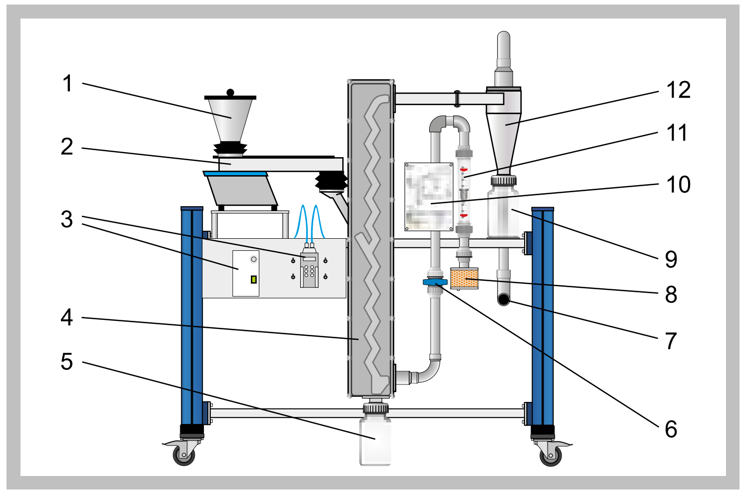
Activated carbon in different particle sizes is recommended for use as the feed material. For particle size analyses of the feed and of the coarse and fine material, a balance and a screening machine (CE 264) are recommended.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

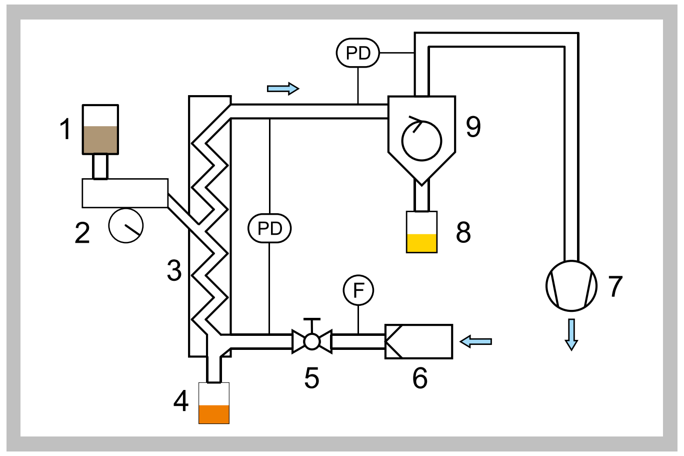
Learning Objectives / Experiments

- learning the fundamental principle of wind sifting (gas flow classification)
- sorting
  * coarse material fraction
  * fine material fraction
  dependent on solid mass flow rate and volumetric air flow rate
- classifying (with CE 264)
  * fraction balance
  * separation function
  * separation size
  * sharpness of separation
  dependent on solid mass flow rate and volumetric air flow rate
- pressure losses of
  * sifter
  * cyclone
  dependent on solid mass flow rate and volumetric air flow rate

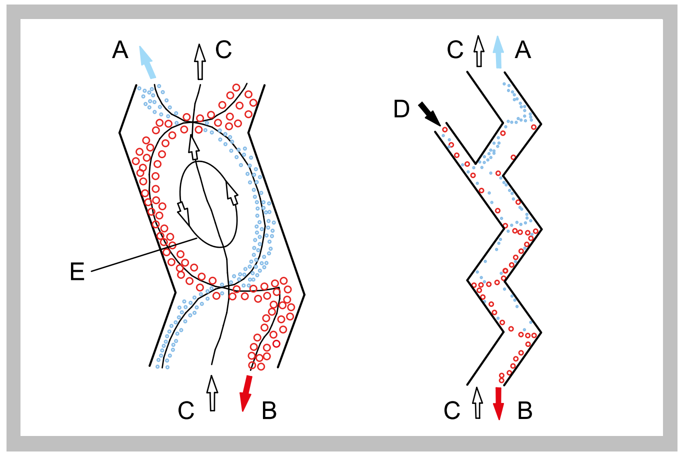
CE 275 Gas Flow Classification



1 feed material tank, 2 vibrating trough, 3 displays and controls, 4 sifter, 5 coarse material tank, 6 valve, 7 connection for fan, 8 filter, 9 fine material tank, 10 process schematic, 11 flow meter, 12 cyclone



1 feed material tank, 2 vibrating trough, 3 sifter, 4 coarse material tank, 5 valve, 6 filter, 7 fan, 8 fine material tank, 9 cyclone;
F volumetric flow rate, PD differential pressure



Fundamental principle of zigzag wind sifting: A fine material, B coarse material, C air flow, D feed material, E vortex wake

Specification

[1] zigzag sifter to separate solid compounds
[2] feed hopper with vibrating trough for feed of solid compound into sifter
[3] dosage of feed material by way of distance of hopper outlet from vibrating trough and frequency of vibrating trough
[4] separation of solid compound into coarse and fine material with air flow in 20-stage zigzag duct
[5] air flow generation by fan; adjustment by valve
[6] separation of fine material from air flow by gas cyclone with tangential inlet
[7] 3 tanks for feed material and coarse and fine materials
[8] recording of volumetric air flow rate and differential pressure through sifter and cyclone

Technical Data

Vibrating trough
- mass flow: max. 10kg/h
- vibration frequency: max. 3000min^{-1}

Zigzag sifter
- height: approx. 1500mm
- cross-sectional area: 40x50mm

Cyclone
- height: approx. 550mm
- diameter: 150mm

Fan
- volumetric flow rate: max. 600m³/h
- power consumption: approx. 3600W

Tanks
- feed hopper: 3L
- coarse material: 2L
- fine material: 2L

Measuring ranges
- cyclone and sifter differential pressures: 0...100mbar
- volumetric flow rate (air): approx. 10...100m³/h

Dimensions and Weight

LxWxH: 1660x790x1930mm (trainer)
Weight: approx. 180kg (trainer)
LxWxH: 660x510x880mm (fan)
Weight: approx. 30kg (fan)

Required for Operation

230V, 50Hz, 1 phase

Scope of Delivery

1 trainer
1 fan
2 packing unit with feed material
2 buckets
1 shovel
1 stopwatch
1 set of instructional material

Order Details

083.27500 CE 275 Gas Flow Classification

CE 264 *Screening Machine*

*** Professional analyser for CE 245 and CE 275**

Technical Description

The screening machine enables users to separate a mixture of solids into several classes of particle sizes. In the screening process, each particle is compared with a screen mesh in terms of size and shape. Depending on their position, particles with an irregular shape may not be able to pass through the mesh. As the screening machine is vibrating, each particle has the possibility to pass through the meshes several times. First the coarser particles are separated in the upper area. The mesh width decreases towards the bottom. To be able to adapt the machine to the respective requirements, several screens with various mesh widths are included in the scope of delivery. Scales enable the user to determine the masses of the separated classes in order to determine the particle size distribution.

Learning Objectives / Experiments

- determination of particle size distributions

Specification

[1] screening machine for particle size analysis as accessory for CE 245 and CE 275
[2] screening duration and vibration height adjustable
[3] 11 screens with different mesh widths
[4] scales for determining the mass fraction of the separated classes

Technical Data

Diameter of the screens: 200mm each
Height of the screens: 50mm each

Measuring ranges of the screening machine
- screening duration: 0...60min
- vibration height: 0...3mm
- mesh width of the screens
  45µm
  63µm
  125µm
  250µm
  500µm
  710µm
  1000µm
  1250µm
  1600µm
  2000µm
  4000µm

Measuring ranges of the scales
- max. weight: 2200g
- resolution: 10mg

Dimensions and Weight

LxWxH: 400x400x800mm (screening machine)
LxWxH: 200x270x100mm (balance)
Weight: approx. 30kg

Required for Operation

230V, 50Hz, 1 phase

Scope of Delivery

1 screening machine
1 set of screens
1 balance
1 manual

Order Details

083.26400 CE 264 Screening Machine

A LOOK INSIDE OUR CUSTOMERS' LABORATORIES

GUNT devices have been used by our satisfied customers for many years in hundreds of technical training institutes.

Highest requirements regarding conception and details: GUNT devices are ideal to convey knowledge through practical application.

CE 280 Magnetic Separation

*** Sorting with a drum-type magnetic separator**

*** Feed through vibrating trough with adjustable throw**

*** Practical experiments on a laboratory scale**

Technical Description

During sorting, a solid compound is separated according to its material characteristics.

Magnetic separation is a method of sorting which utilises the magnetisability of components of a solid compound. Magnetic separators are often used in coal and ore preparation.

In the CE 280, the solid compound to be separated is charged into the feed hopper. A vibrating trough conveys the compound onto a rotating, non-magnetic drum. Its speed can be adjusted by way of a potentiometer. In one area of the drum there is a fixed permanent magnet. Non-magnetisable components drop into a collector tank due to gravity. Magnetisable components adhere to the drum in the area of the magnet, are carried along and drop into a different tank as soon as they are beyond the magnetic zone. The mass flow of the feed material can be adjusted by way of the distance of the hopper outlet from the vibrating trough and by the throw and frequency of the trough. A mixture of sand and small steel items, such as hexagon nuts, is recommended for use as the feed material.

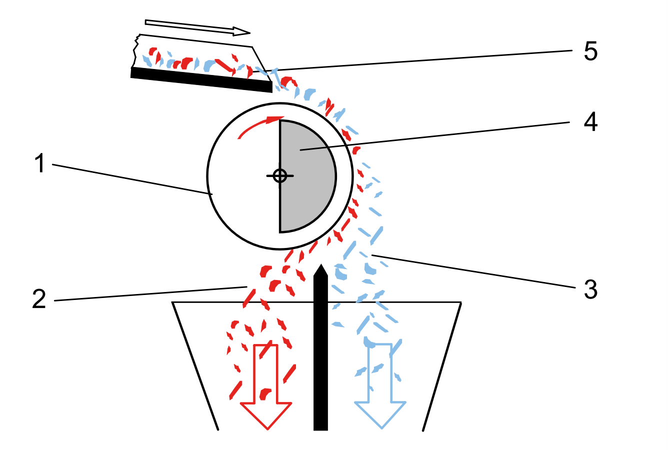
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- learning the fundamental principle and the method of operation of a drum-type magnetic separator
- efficiency of separation process dependent on
  - * mass flow of feed material
  - * mixing ratio of feed material
  - * type of feed material
  - * drum rotation speed

CE 280 Magnetic Separation

1 feed hopper with height adjuster, 2 vibrating trough controls, 3 magnetic separator controls, 4 solid compound tank, 5 magnetic materials tank, 6 non-magnetic materials tank , 7 magnetic separator, 8 vibrating trough



Fundamental principle of drum-type magnetic separators: 1 rotating drum (non-magnetic), 2 magnetisable components, 3 non-magnetisable components, 4 permanent magnet, 5 feed material

Specification

[1] drum-type magnetic separator for separation of magnetisable components from a solid compound
[2] separation by a fixed permanent magnet in an area of a rotating, non-magnetic drum
[3] feed hopper with vibrating trough for feed of solid compound to drum
[4] dosage of feed material by way of distance of hopper outlet from vibrating trough, throw and frequency of vibrating trough
[5] drum rotation speed adjustable by electric motor with potentiometer
[6] 2 steel tanks for separated fractions and 1 tank for solid compound

Technical Data

Feed hopper capacity: 25L
Vibrating trough
- throw: 0,2...1,5mm
- vibration frequency: 50Hz or 100Hz
Drum
- diameter: 220mm
- length: 300mm
- magnetic field range: 180°
- speed: 0...30min^{-1}
Motor
- power consumption: 250W
Max. particle size
- non-magnetic: 20mm
- magnetic: 20mm
Tanks
- 2x 15L
- 1x 20L

Dimensions and Weight

LxWxH: 1500x700x1700mm
Weight: approx. 175kg

Required for Operation

230V, 50Hz, 1 phase

Scope of Delivery

1 trainer
1 shovel
1 set of instructional material

Order Details

083.28000 CE 280 Magnetic Separation

BASIC KNOWLEDGE

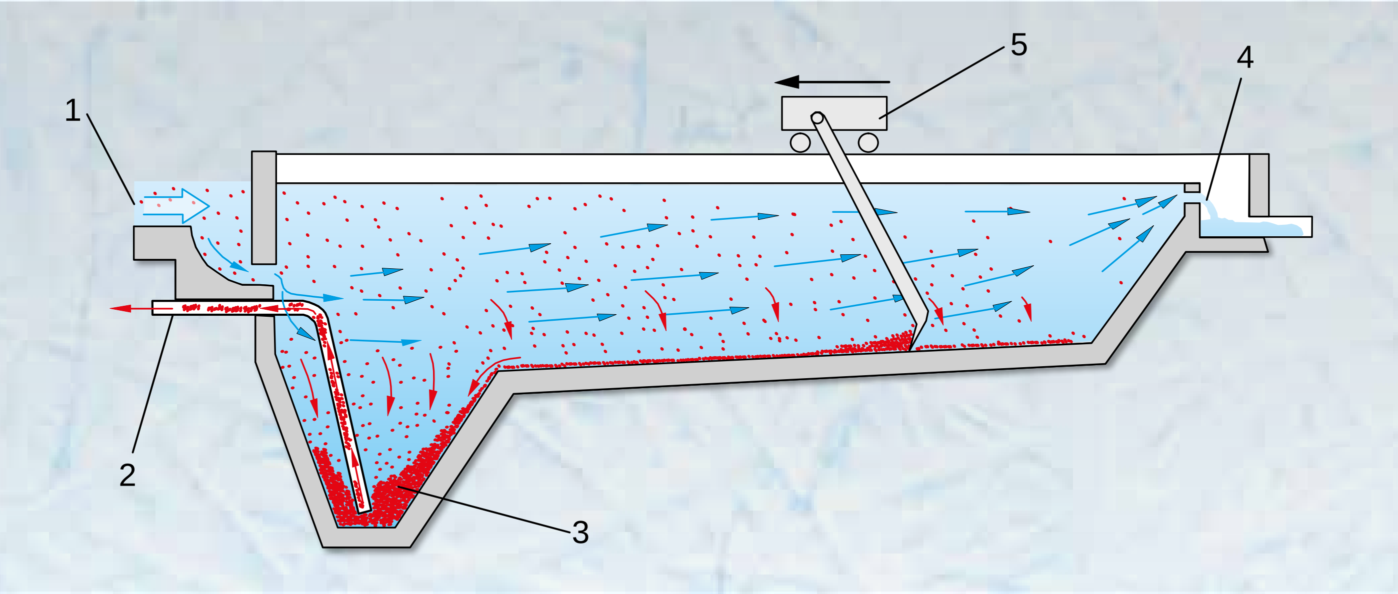
SEDIMENTATION

Mechanical process engineering in many cases utilises gravity to separate different phases. Gravity can be used to separate a solid phase off from a fluid. When solid particles are suspended in a fluid, gravity causes them to sink. For this to happen, the density of the solid must be greater than that of the fluid. The process is termed sedimentation. Fluid is the umbrella term for gases and liquids. It is used because most physical laws apply equally to both.

In terms of the **separation of solids from gases** the phrase “dust separation” is also used. The solid phase may, on the one hand, be a usable material, on the other hand, it may be an unwanted material (gas purification). In gravity separators the gas flow is routed at slower velocity through a separator channel. On their way, the particles sink and are collected.

In practice the **separation of solid/liquid mixtures** (suspensions) takes place in sedimentation tanks through which the suspension continuously flows. The shape of the base may be rectangular or circular.

In rectangular tanks the suspension flows in on one side and flows out over the rim on the opposite side. On the way, the solid particles sink to the bottom of the tank. The tank floor is positioned at an angle to aid discharge of the solid material. There are also devices by which the settled solid (sludge) can be cleared from the tank bottom. Sedimentation tanks are mostly used in water treatment.



Sedimentation tank:
***1** wastewater inlet, **2** sludge extractor, **3** sludge hopper, **4** clean water overflow*
***5** cart for sludge clearing*

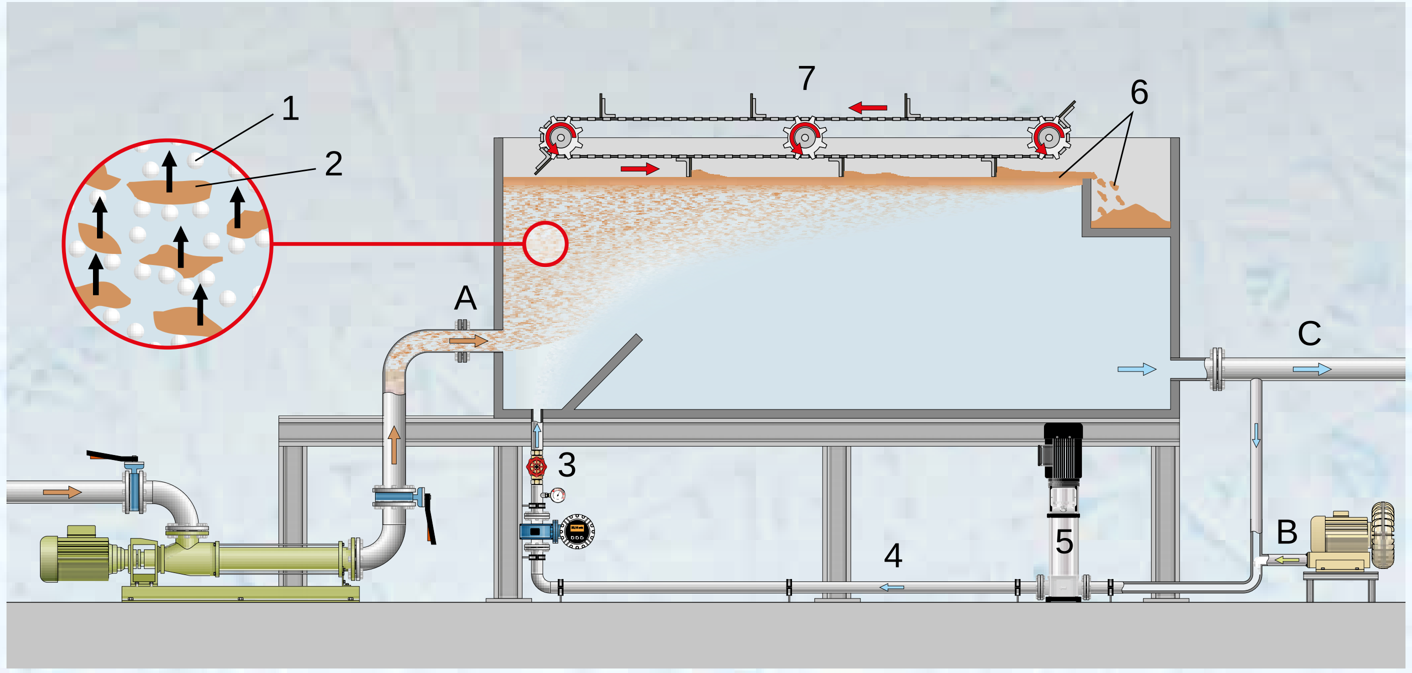
The *settling velocity* of the particles is the key variable in the design of sedimentation tanks and separator channels. It is directly related to the particle size, the particle shape (flow resistance) and the difference in density between the fluid and solid. If the particles in a suspension are very fine, or if the difference in density between the fluid and solid is slight, the settling velocity is very low. A technically useful separation by means of sedimentation is then not possible. Another variable influencing the settling velocity in liquids is the concentration of solid particles. At high concentrations, sedimentation is hindered. As the concentration increases, the so-called cluster settling velocity becomes less than the velocity of the single particles.

BASIC KNOWLEDGE

FLOTATION

Suspended solids with a density close to or less than that of water can’t be removed by sedimentation. Such solids would sediment only very slowly or would remain suspended. The aim of flotation is to increase the buoyancy of the solids. This is done by forming small gas bubbles that attach to the solids. This makes them rise to the surface of the water where they can be skimmed off. It is required that the solids should be hydrophobic. That means that they are more wettable with air than with water. The separated solids are termed float. The key factor influencing flotation is the size of the gas bubbles. The smaller they are the less will be their rate of rise. This is compensated by larger numbers of small gas bubbles attaching to the solids than large bubbles.

The main process used in water treatment is **dissolved air flotation.** Another flotation variant is electro-flotation. The two processes differ primarily in the way the gas bubbles are produced.



Fundamental principle of dissolved air flotation:
***1** air bubbles, **2** solids, **3** relief valve, **4** recycle water, **5** pump, **6** float, **7** scraper*
***A** raw water, **B** compressed air, **C** treated water*

Dissolved air flotation

Dissolved air flotation uses the fact that the solubility of air in water increases as the pressure rises at constant temperature. Some of the treated water is saturated with air under pressure (recycle water). The recycle water is then injected into the flotation tank through a special valve that causes an instantaneous reduction in pressure (relief valve). The sudden relief to atmospheric pressure causes the dissolved air to precipitate as a cloud of small bubbles. A scraper clears the float from the surface of the water. To improve the performance of the process, coagulants and flocculants may be added to the raw water. This helps to optimise the size of the solids so that more air bubbles can be attached to the solids.

Application examples

Industrial water treatment

- paper industry
- food industry
- oil refineries
- plastics industry

Domestic water treatment

- secondary clarification, if the activated sludge sediments very slow
- supplementing or replacing primary clarification

INSTRUCTIONAL MATERIAL AND SOFTWARE

GUNT's policy is:

High-quality hardware and clearly laid-out instructional materials ensure the teaching and learning success of an experimental unit. The core elements of the instructional material provided to accompany the units are reference experiments conducted by ourselves. The description of the experiment incorporates the detailed set-up, through to interpretation of the results obtained. A group of experienced engineers devise and maintain the accompanying instructional material.

Our software – in our context meaning computerised data acquisition programs – always comes with comprehensive online help to explain the features offered the detailed use of the program. GUNT software is developed and written in-house by another group of experienced engineers.

04/2007

TZ 200.11 MONTAGESET BIEGEVORRICHTUNG

Technische Unterlagen im Vergleich

Grundplatte und benachbarte Teile

Grundplatte und benachbarte Teile		
Pos.	Anzahl	Benennung
2	1	Grundplatte
4	1	Unterstempel
18	1	Spannplatte
20	2	Zylinderschraube M5x12
22	2	Zylinderschraube M4x12

Explosionszeichnung

Gesamtzeichnung

Alle Rechte vorbehalten G.U.N.T. Gerätebau GmbH, Barsbüttel 01/2007

2 Montage/Demontage – Montageplan

11/2007

MT 158 MONTAGEÜBUNG KUGELHAHN UND ABSPERRVENTIL

5.4 3-Wege-Kugelhahn

In der Praxis findet man 3-Wege-Kugelhähne mit einer L- oder T-Bohrung in der Kugel. Somit ist es möglich, die Durchflussrichtungen zu ändern oder auch zwei Fluidströme miteinander zu mischen.

T-Bohrung L-Bohrung

-Bohrung.

C nach A

C nach B

38

11/2007

MT 158 MONTAGEÜBUNG KUGELHAHN UND ABSPERRVENTIL

4.3.2 Schrägsitzventil

Die Richtung der Abschlusskörperbewegung steht z.B. im Winkel von 45° zur Hauptströmungsrichtung.

Bei einem Schrägsitzventil ist der Umlenkungsgrad der Strömung geringer als bei einem Geradsitzventil. Die Druckverluste fallen deshalb vergleichbar geringer aus.

HM 700.06 Schrägsitzventil

Diese Bauform gehört zu den geraden Durchgangsventilen, da die Rohrleitungsanschlüsse gerade, d.h. in einer Achse verlaufen.

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4 Sitzventile 31

CE 115 Fundamentals of Sedimentation

*** Separation of suspensions by sedimentation**

Technical Description

Sedimentation is often used to clarify suspensions. In the process, the solid particles move downwards in a liquid owing to their density.

Using CE 115, the sedimentation processes in different suspensions can be investigated and compared. Five transparent cylindrical tanks are provided for the purpose. The suspensions are prepared in measuring cups, poured into the removable tanks, and mixed by shaking. The tanks are then mounted vertically on the experimental unit. To aid observation of the sedimentation process, the tanks are backlit.

Learning Objectives / Experiments

- determination and comparison of the settling velocities of solids in suspensions dependent on the solid density and concentration and the liquid density and viscosity
- influence of coagulants on the settling velocity

Specification

[1] experiments in the fundamentals of sedimentation
[2] 5 transparent tanks with scale for comparison of the settling velocities of solids in various suspensions
[3] tanks removable for filling, mixing and cleaning
[4] tanks backlit by fluorescent tubes to aid observation
[5] 3 measuring cups for preparation of suspensions
[6] pycnometer to determine the density of the liquids and solids
[7] stopwatch to record the sedimentation time
[8] recommended accessories: balance, coagulant

Technical Data

Tanks
- length: 1000mm
- inside diameter: 42mm
- scale division: 1mm
- material: PMMA

Fluorescent tubes
- power: 6x 18W

Measuring cups
- capacity: 2000ml
- scale division: 50ml

Stopwatch
- resolution: 1/100sec

Dimensions and Weight

LxWxH: 750x460x1160mm
Weight: approx. 53kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase
Coagulant (recommendation)

Scope of Delivery

1 experimental unit
3 measuring cups
1 stopwatch
1 pycnometer
1 set of instructional material

Order Details

083.11500 CE 115 Fundamentals of Sedimentation

G.U.N.T Gerätebau GmbH, Hanskampring 15-17, D-22885 Barsbüttel, Phone +49 (40) 67 08 54-0, Fax +49 (40) 67 08 54-42, E-mail sales@gunt.de, Web http://www.gunt.de

HM 142 Separation in Sedimentation Tanks

*** Solid/liquid separation in a sedimentation tank**

*** Visualisation of flow conditions**

Technical Description

In sedimentation tanks, solids are separated out of suspensions under the influence of gravity. For this, the density of the solid particles must be greater than that of the liquid.

With HM 142, the factors influencing the separation process in sedimentation tanks can be investigated. First a suspension of water and precipitated calcium carbonate is prepared in a tank. A pump delivers the suspension to the sedimentation tank. In the inlet area of the sedimentation tank the suspension intermingles with fresh water. The mixture flows over an inlet weir. On their way through the sedimentation tank the solids sink to the bottom. The treated water flows out by way of the weir at the sedimentation tank outlet.

The solid concentrations at the sedimentation tank inlet and outlet are determined by means of two Imhoff cones. The mass separated in the sedimentation tank can be determined from the difference between them. The flow rates of the suspension and the fresh water are adjusted by valves and indicated by flow meters. This enables the mixing ratio - and thus the solid concentration of the mixture - to be adjusted. In order to ensure a uniform mix of the suspension and prevent premature sedimentation, a portion of the suspension is fed back into the suspension tank by way of a bypass. To investigate the flow conditions, ink can be added with a piston burette to the fresh water stream as a tracer substance. The mixed-in volume of ink is entered using keys and indicated on a display. To provide enhanced observation of the flow conditions and settling processes, the sedimentation tank is made of transparent material.

A baffle plate can be positioned in the sedimentation tank to impede the flow. Its horizontal and vertical positioning in the sedimentation tank is adjustable. This enables the flow conditions and the efficiency of the separation process to be influenced.

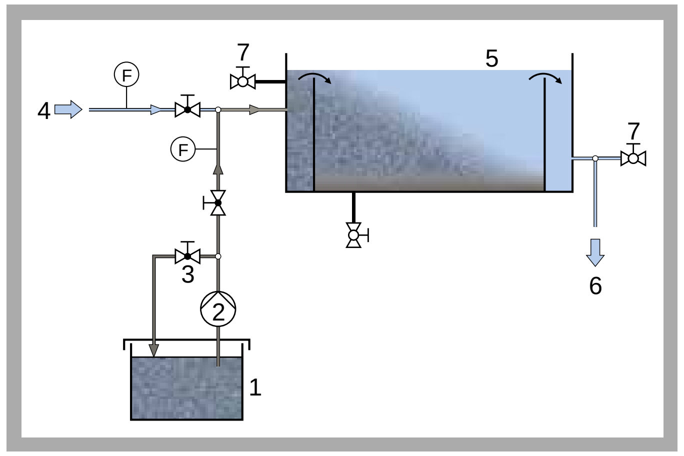
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- learning the fundamental principle of separation of solids from suspensions in a sedimentation tank
- efficiency of the separation process dependent on
  - * solid concentration of suspension
  - * flow rate
  - * position of baffle plate
- investigation of flow conditions dependent on
  - * flow rate
  - * position of baffle plate

HM 142 Separation in Sedimentation Tanks

1 suspension flow meter, 2 fresh water flow meter, 3 switch box, 4 bypass valve, 5 suspension pump, 6 suspension tank, 7 storage bin, 8 outlet, 9 sedimentation tank, 10 baffle plate, 11 fresh water/suspension mixing zone



1 suspension tank, 2 pump, 3 bypass valve, 4 fresh water inlet, 5 sedimentation tank, 6 treated water outlet, 7 sampling points; F flow rate

Determination of solid concentrations at sedimentation tank inlet and outlet by Imhoff cones

Specification

[1] separation of suspensions by sedimentation in transparent sedimentation tank
[2] tank with pump to prepare and deliver a suspension comprising water and precipitated calcium carbonate
[3] bypass to tumble and homogenise the suspension
[4] mixing of the suspension with fresh water in sedimentation tank inlet zone
[5] adjustment of fresh water and suspension flow rate by valves
[6] precise piston burette for metering of ink to visualise flow conditions in the sedimentation tank
[7] influencing of flow conditions in the sedimentation tank with baffle plate that can be positioned
[8] determination of solid concentrations at sedimentation tank inlet and outlet by Imhoff cones

Technical Data

Sedimentation tank
- LxWxH: 1000x400x230mm
- capacity: approx. 80L
- material: plexiglass

Suspension tank
- capacity: approx. 100L
- material: stainless steel

Pump
- max. flow rate: 75L/min
- max. head: 5m

Piston burette
- metering accuracy: 0,15% of nominal volume
- volume adjustment range: 0...20ml
- resolution: 0,01ml

Imhoff cones
- capacity: each 1000ml

Measuring ranges
- flow rate (fresh water): 60...640L/h
- flow rate (suspension): 0...1,9L/min

Dimensions and Weight

LxWxH: 1900x670x1590mm
Weight: approx. 190kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz, 1 phase
Water connection (200...300L/h), drainage

Scope of Delivery

1 trainer
1 piston burette
2 Imhoff cones
1 packing unit of precipitated calcium carbonate
1L ink
1 set of instructional material

Order Details

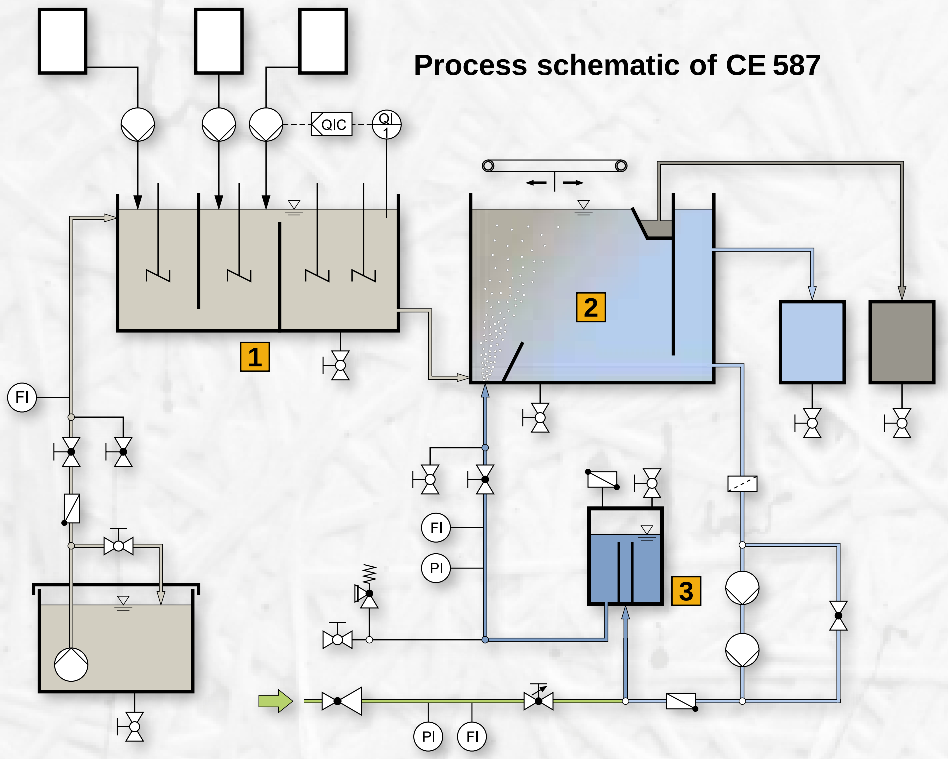
070.14200 HM 142 Separation in Sedimentation Tanks

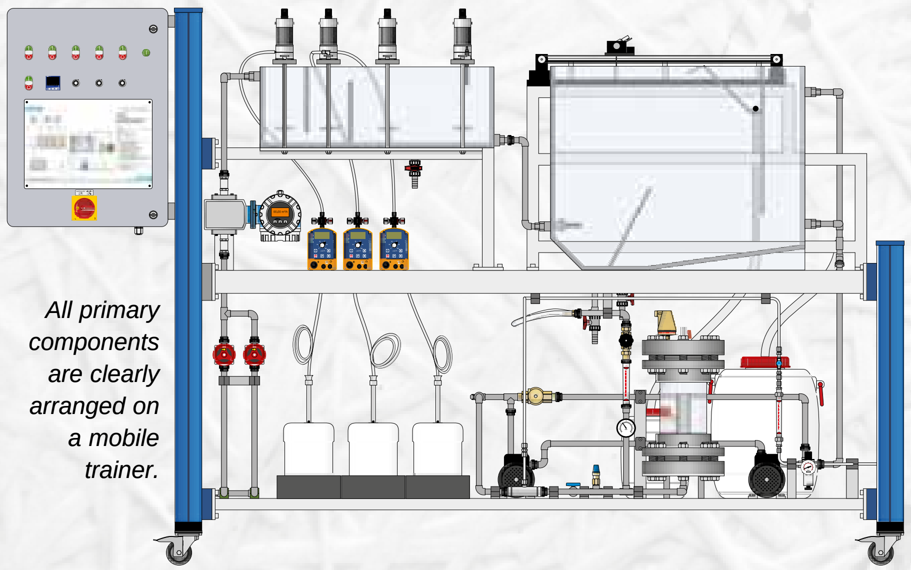
CE 587 DISSOLVED AIR FLOTATION

The flotation process most frequently used in water treatment is dissolved air flotation. CE 587 enables this process to be demonstrated clearly.

- continuous and practical process
- conditioning of the raw water by flocculation
- flotation tank with electrically driven scraper
- control of pH value
- high quality instrumentation and control

Process schematic of CE 587





All primary components are clearly arranged on a mobile trainer.

1 *Flocculation tank with stirring machines*

2 *Flotation tank with scraper*

3 *Components to generate the bubbles*

University of Applied Sciences in Münster (Germany)

Be our next satisfied customer.

The electrically driven scraper clears the float from the surface of the water.

The recycle water enters the flotation tank:
The sudden relief to atmospheric pressure causes the dissolved air to precipitate as a cloud of small bubbles.

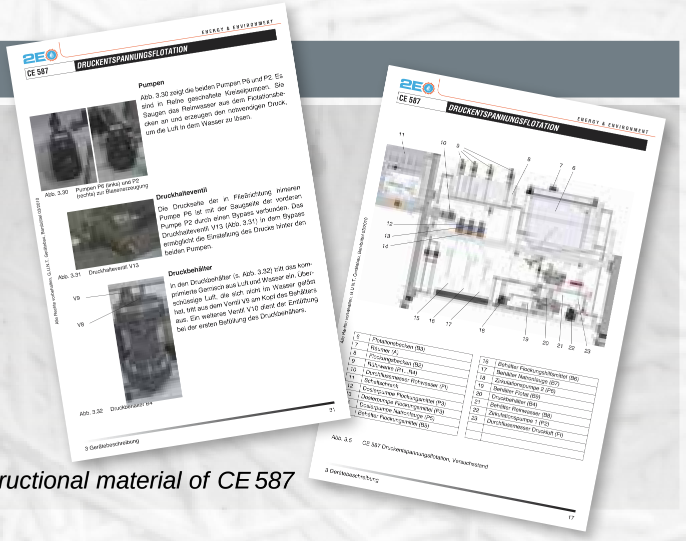
You can find an interesting film of CE 587 on our 2E website **www.gunt2E.de**

Use of high quality components: Magneto-inductive flow rate sensor and metering pumps

THE INSTRUCTIONAL MATERIAL

We have compiled a comprehensive range of instructional material for the CE 587 which will greatly assist you in getting to know the system and in preparing your lessons and laboratory experiments and exercises.

Materials delivered as paper printouts in a folder and additionally as PDF files on a CD.



Instructional material of CE 587

CE 587 Dissolved Air Flotation

The illustration shows: Supply unit (left) and trainer (right)

*** Demonstration of dissolved air flotation**

*** Flocculation to condition the raw water**

*** Scraper to remove the float**

Technical Description

CE 587 demonstrates the clarification of raw water containing solids using the dissolved air flotation process.

First, a suspension (raw water) is prepared in a tank. From here the raw water flows into a flocculation tank divided into three chambers. By adding a coagulant in the first chamber the repulsive forces between the solid particles are cancelled out. The solid particles combine into flocs. To create larger flocs a flocculant is added in the second chamber. The coagulant causes a drop of the pH value. By adding caustic soda the pH value of the water can be increased again. In the following third chamber of the flocculation tank low flow velocities are present to prevent any turbulence. Turbulence would impede the formation of flocs.

From the flocculation tank the raw water enters the flotation tank. A part of the treated water is removed from the flotation tank and saturated with air under pressure. This water (recycle water) enters via a relief valve so that it suddenly expands to atmospheric pressure. This creates minute air bubbles which attach to the flocs. This makes the flocs rise to the surface of the water. Using a scraper the floating flocs (float) can be moved into a collection channel.

Flow rates, pressures and pH values are masured. The pH value can additionally be controlled. The pressure of the recycle water can be adjusted.

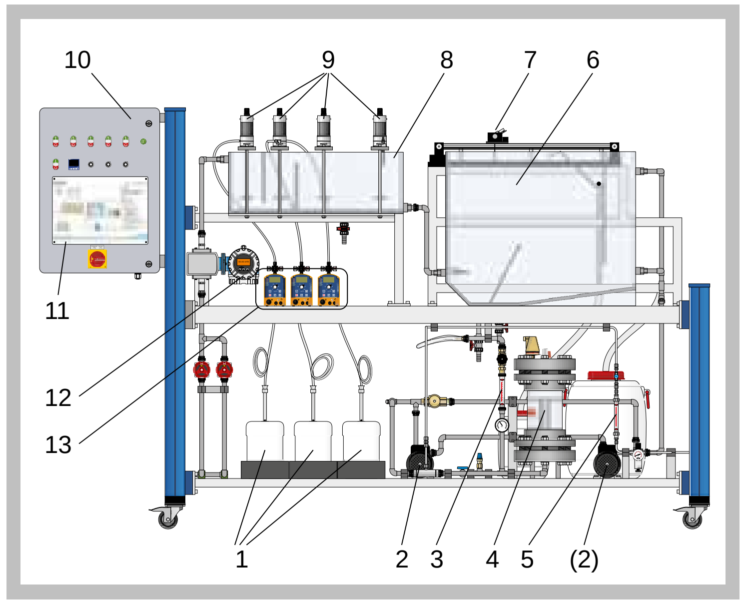
Trivalent metallic salts are usually well suited as coagulants. Common flocculants are organic polymers. Powdered activated carbon can be used to produce the raw water.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

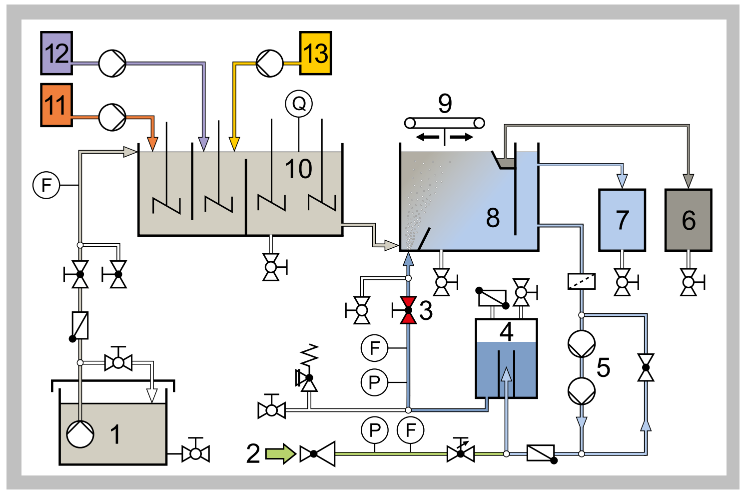
Learning Objectives / Experiments

- functional principle of dissolved air flotation
- creation of a stable operating state
- effects of various parameters
  - * coagulant concentration
  - * flocculant concentration
- determination of the hydraulic loading rate (rising velocity)

CE 587 Dissolved Air Flotation



1 chemical tanks, 2 circulation pumps, 3 flow meter (recycle water), 4 pressure tank, 5 flow meter (air), 6 flotation tank, 7 scraper, 8 flocculation tank, 9 stirring machines, 10 switch cabinet, 11 process schematic, 12 electromagnetic flow rate sensor (raw water), 13 metering pumps



1 raw water, 2 compressed air, 3 relief valve, 4 pressure tank, 5 circulation pumps, 6 sludge (float), 7 treated water, 8 flotation tank, 9 scraper, 10 flocculation tank, 11 coagulant, 12 flocculant, 13 caustic soda; F flow rate, P pressure, Q pH value

Specification

[1] removal of solids from raw water using dissolved air flotation
[2] conditioning of the raw water by flocculation
[3] 3 Metering pumps for chemicals
[4] flocculation tank with 3 chambers and 4 stirring machines
[5] flotation tank with electrically driven scraper
[6] pressure tank and 2 circulation pumps
[7] relief valve
[8] separate supply unit with tank and pump for raw water
[9] electromagnetic flow rate sensor
[10] measurement of flow rate, pressure and pH value
[11] control of the pH value

Technical Data

Tanks
- flotation tank: 150L
- flocculation tank: 45L
- raw water: 300L
- treated water: 80L
- sludge (float): 15L

Raw water pump
- max. flow rate: 135L/min
- max. head: 7,0m

Circulation pumps
- max. flow rate: each 18L/min
- max. head: each 50m

Metering pumps
- max. flow rate: each 2,1L/h

Stirring machines
- max speed: each $600min^{-1}$

Measuring ranges
- flow rate (raw water): 0...550L/h
- flow rate (recycle water): 30...320L/h
- flow rate (air): 20...360L/h
- pH value: 1...14
- pressure (recycle water): 0...6bar

Dimensions and Weight

LxWxH: 1560x790x1150mm (supply unit)
LxWxH: 3100x790x1950mm (trainer)
Total weight: approx. 550kg

Required for Operation

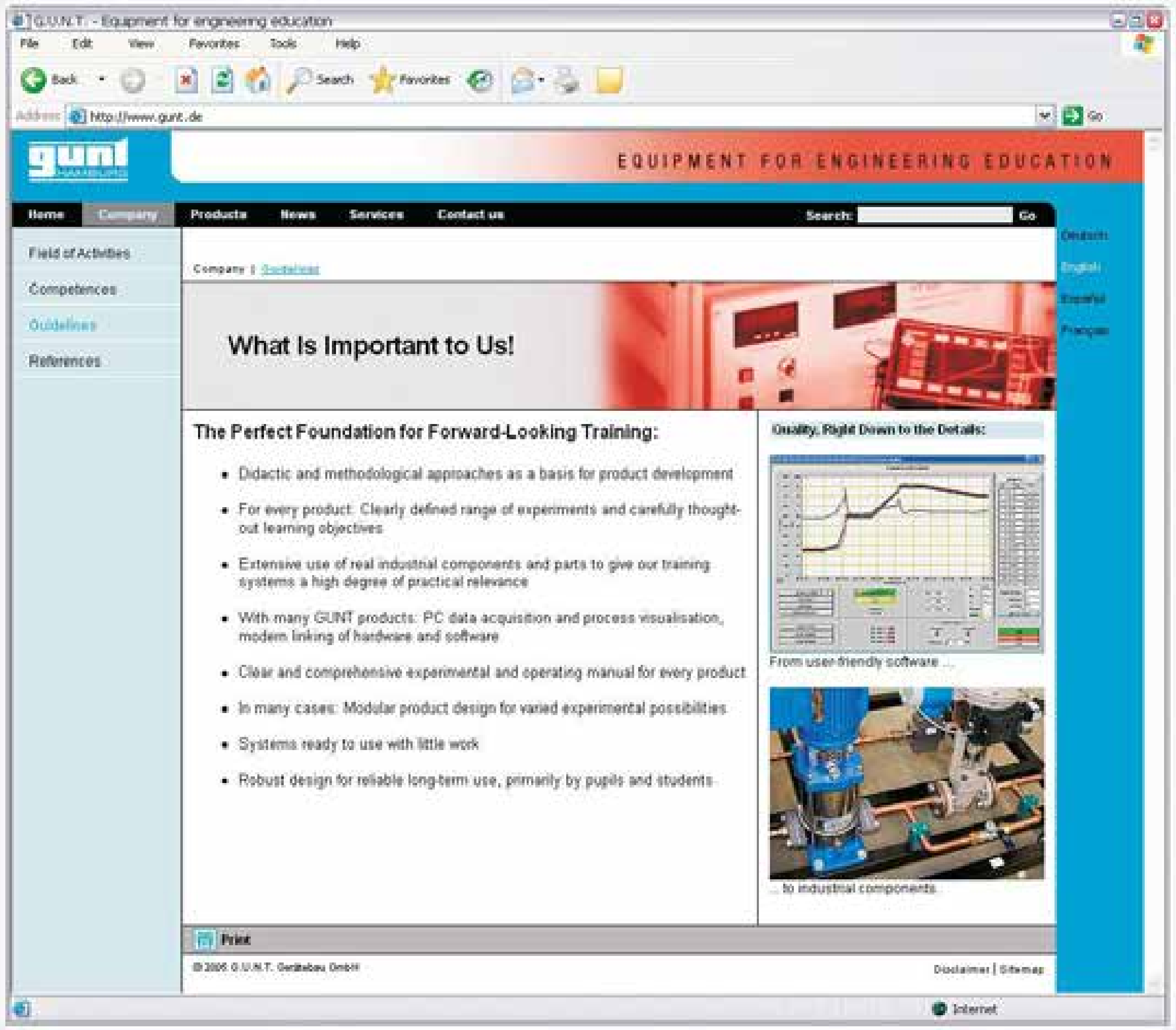
230V, 50/60Hz, 1 phase or 120V, 60Hz, 1 phase
Water connection, drainage, compressed air, caustic soda, iron(III) sulfate, flocculant, powdered activated carbon (recommendation)

Scope of Delivery

1 supply unit
1 trainer
1 set of hoses
1 set of instructional material

Order Details

083.58700 CE 587 Dissolved Air Flotation



What Is Important to Us!

The Perfect Foundation for Forward-Looking Training:

- Didactic and methodological approaches as a basis for product development
- For every product: Clearly defined range of experiments and carefully thought-out learning objectives
- Extensive use of real industrial components and parts to give our training systems a high degree of practical relevance
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- Clear and comprehensive experimental and operating manual for every product
- In many cases: Modular product design for varied experimental possibilities
- Systems ready to use with little work
- Robust design for reliable long-term use, primarily by pupils and students

Quality, Right Down to the Details:

From user-friendly software ...

... to industrial components

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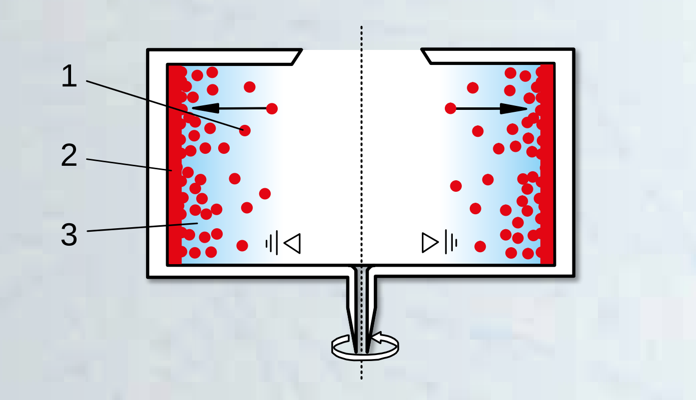
BASIC KNOWLEDGE

SEPARATION IN A CENTRIFUGAL FORCE FIELD



Sedimentation centrifuge:
***1** solid particles, **2** sediment, **3** liquid*

As well as gravity, centrifugal force can also be used as the driving force for phase separation processes. The centrifugal force can be generated either by guiding the flow of the fluid, or by rotating vessels (centrifuges). The difference in density between the fluid and the solid particle results in the separation. The higher-density solid particles are drawn outwards by the centrifugal force more strongly than the fluid particles.

The forces occurring in the centrifugal force field of a **centrifuge** may be many times higher compared to those produced by gravity. Consequently, smaller, specifically lighter particles can be separated in a centrifugal force field than in a gravity field.

Sedimentation and filter centrifuges can be used to separate solid/liquid compounds:

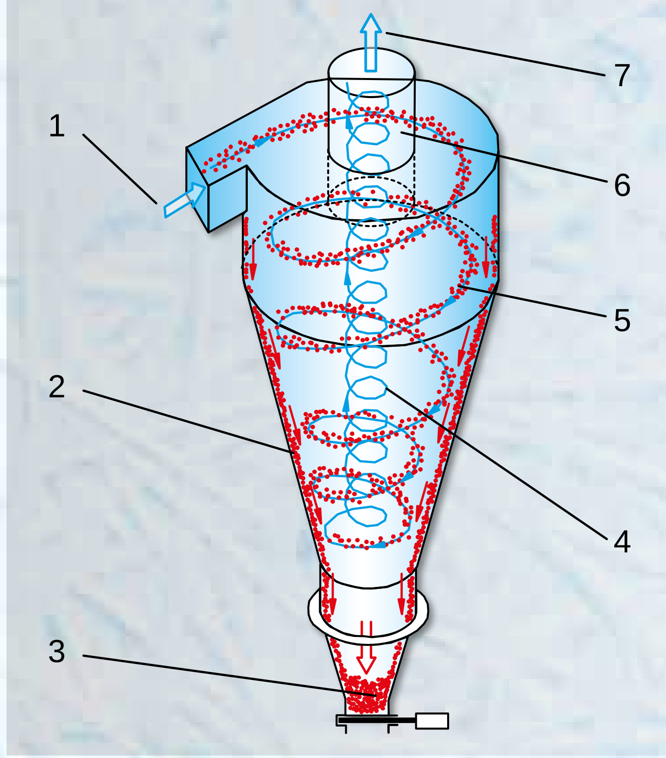
- In *sedimentation centrifuges,* the solid particles collect as sediment on the jacket wall. Sedimentation centrifuges may also have internal fittings such as inclined discs set at an oblique angle to the centrifugal force field (disc centrifuges). This layout reduces the settling distance and time. Disc centrifuges can also be used to separate emulsions such as water and oil.
- In *filter centrifuges,* the jacket of the rotating vessel has holes in it. On the inside of the jacket is a filter medium (a fine sieve or filter cloth). The centrifugal forces drive the suspension towards the filter medium, where the solid particles form a filter cake.

In **cyclones**, the centrifugal force needed for separation is achieved by guiding the fluid flow. Cyclones are cylindrical at the top and taper downwards.

The solid-laden fluid enters the cyclone tangentially at the top and is forced into a revolving flow by the cyclone wall. A rotating (primary), downward-moving vortex is created. At the bottom of the cyclone the primary vortex is reversed. As the secondary vortex, the fluid moves upwards in the centre of the cyclone towards the immersion tube, where it exits. The main separation process takes place in the primary vortex. Owing to the centrifugal forces and the difference in density between the fluid and the solid, the solid particles move towards the wall.

In a *gas cyclone,* the solid particles slide downwards and collect at the bottom. Gas cyclones are in widespread use because they can also be used to separate solids from hot gases.

In a *hydrocyclone,* the solid-enriched portion of the liquid close to the wall spirals downwards to the bottom where - in contrast to the gas cyclone - it is continuously discharged. Hydrocyclones are used, for example, in the cleaning of contaminated soils.



*Gas cyclone: **1** raw gas, **2** separated dust,*
***3** collected dust, **4** secondary vortex, **5** primary vortex*
***6** immersion tube, **7** dedusted gas*

CE 282 Disc Centrifuge

*** Continuous separation of emulsions**

*** Maintenance and inspection exercises possible**

*** Practical experiments on a laboratory scale**

Technical Description

A disc centrifuge can be used to separate mixtures of immiscible liquids.

The emulsion to be separated is prepared in a stirred tank. Water/oil is recommended for use as the emulsion. A stirring machine with a speed control mixes the two liquid phases. In the course of the mixing process the oil droplets are distributed ever more finely in the water. When the droplet sizes are smaller the emulsion remains stable for longer.

A pump delivers the emulsion up into the centre of the rotating centrifuge. The emulsion is delivered by way of the distributor base via riser ducts into the disc intermediate chambers. The driving force of the separation process is centrifugal force. It ensures that the specifically heavier liquid droplets (water) are drawn more strongly towards the outside than the specifically lighter liquid droplets (oil). The settling distance and time are shortened by the disc arrangement set at an oblique angle to the field of acceleration. On the underside of the rotating discs the specifically heavier portion of the emulsion moves downwards and outwards. The lighter portion flows inwards on the top side of the discs. The separated liquids exit the centrifuge by way of outlets and can be collected in tanks.

The rotation speed of the centrifuge can be adjusted by way of a potentiometer. A valve is used to adjust the flow rate of the emulsion due to be separated. Various types of stirrer are available to perform the stirring. A photometer is recommended for analysis of the separated fractions.

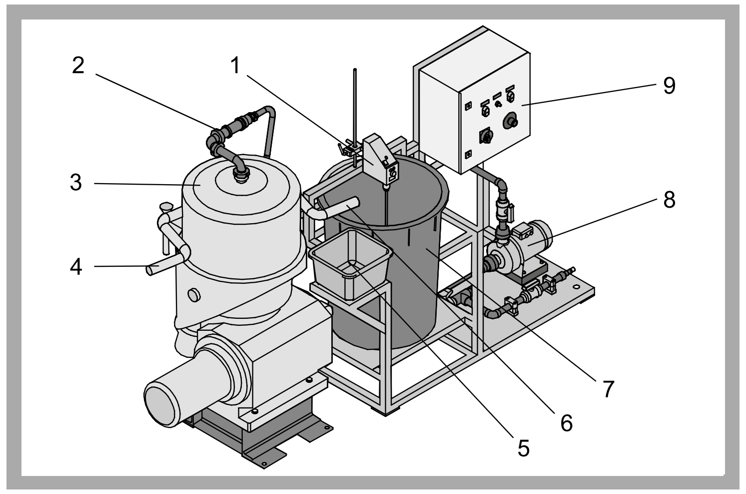
The operating and service instructions form the basis for learning how to perform an extensive range of maintenance and inspection operations on the centrifuge.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

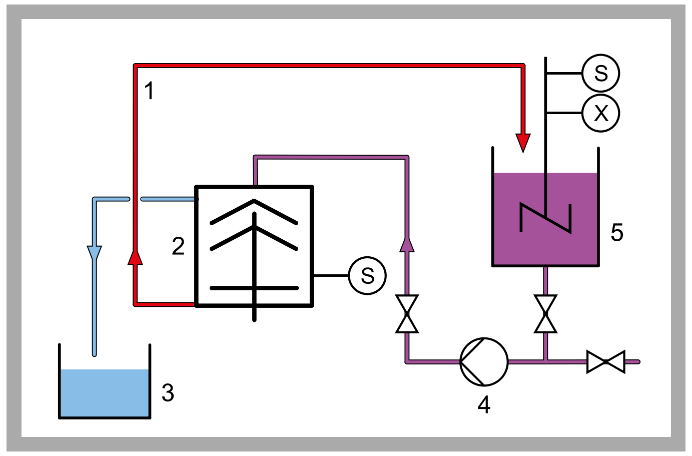
Learning Objectives / Experiments

- production of stable emulsions with different types of stirrer
- learning the fundamental principle of disc centrifuges
- influence of rotation speed and feed flow rate on separation result
- characteristic of concentration of the light phase in the stirred tank over time (with photometer)
- startup/shutdown and operation of a disc centrifuge
- maintenance
- cleaning
- inspection

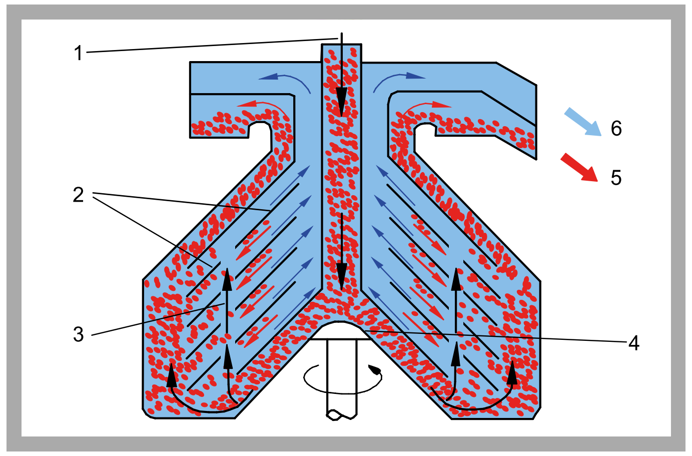
CE 282 Disc Centrifuge



1 stirring machine, 2 emulsion inlet, 3 centrifuge, 4 light phase outlet, 5 light phase collector tank, 6 heavy phase outlet, 7 stirred tank, 8 pump, 9 switch box with controls



1 heavy phase, 2 disc centrifuge, 3 light phase, 4 pump, 5 emulsion stirred tank; S speed, X torque



Fundamental principle of disc centrifuges: 1 emulsion inlet, 2 discs, 3 riser duct, 4 inlet base, 5 heavy phase outlet, 6 light phase outlet

Specification

[1] continuous separation of emulsions with a disc centrifuge
[2] HDPE tank with stirring machine to produce an emulsion
[3] centrifugal pump to deliver the emulsion to the centrifuge
[4] adjustment of emulsion flow rate by valve
[5] centrifuge speed adjustable by potentiometer
[6] speed-controlled stirring machine with digital torque indicator
[7] 3 interchangeable stirrers
[8] collector tank for separated phase

Technical Data

Disc centrifuge
- power consumption: 7500W
- max. usable diameter: approx. 300mm
- max. speed: 6480rpm

Stirring machine
- power consumption: 140W
- speed: 30...1000rpm

Stirrer
- 2x paddle stirrers: 3/10 holes
- 1x stirrer with 3 blades

Centrifugal pump
- max. flow rate: 300L/min
- max. head: 9,5m

Tanks
- stirred tank: 200L
- collector tank: 14L

Measuring ranges
- speed (centrifuge): approx. 0...8000min^{-1}
- speed (stirring machine): 30...1000min^{-1}
- torque (stirring machine): 0...200Ncm

Dimensions and Weight

LxWxH: 3000x1000x1800mm
Weight: approx. 1100kg

Required for Operation

400V, 50Hz, 3 phases
Water connection: 200...300L/h
Special foundations and drainage required

Scope of Delivery

1 disc centrifuge
1 set of hoses
1 set of tools
1 set of instructional material

Order Details

083.28200 CE 282 Disc Centrifuge

CE 235 Gas Cyclone

The illustration shows: trainer (left) and fan (right).

- **Solid separation with a gas cyclone**
- **Transparent cyclone to observe the separation process**
- **Practical experiments on a laboratory scale**

Technical Description

One area of application of gas cyclones is the pre-filtration of solids from gases. Gas cyclones have no moving parts, and so are low-maintenance systems. Gas cylones can also be used in conjunction with high gas temperatures. For these reasons they are in widespread use.

This trainer was developed in cooperation with the **Institute for Solids Process Engineering and Particle Technology at TU Hamburg-Harburg**. A disperser is used to disperse the feed material (quartz powder recommended) finely in an air flow. The air flow laden with solid material (raw gas) in this way is fed tangentially into the cyclone at the top. In the cyclone, the air flow moves downwards as a rotating primary vortex. At the bottom of the cyclone the vortex is reversed. In the middle of the cyclone it moves as a secondary vortex back up towards the immersion tube, where the cleaned gas emerges from the cyclone. The main separation process takes place in the primary vortex. Owing to the centrifugal forces and the difference in density between the air and the solid, the coarse solid particles move towards the wall. They slide down the wall and are collected in a tank at the bottom of the cyclone. No complete separation of the entire solid material takes place. The fine particles which are smaller than the separation size are ideally discharged from the immersion tube at the top with the secondary vortex. This fine material is separated out of the air flow by a filter. The separation size defines the theoretical boundary between the fine and coarse material.

The solid content of the raw gas can be adjusted by means of the disperser and a valve for the volumetric air flow rate. To prevent loading of the air flow with particles upstream of the disperser, the drawn-in room air is filtered. A fan generates the air flow. Pressure measurement points at the relevant positions in the trainer enable to determine the pressure loss.

Using a suitable analysis device (such as a diffraction spectrometer), a separation function can be produced and the separation size determined.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- influence of solid content and volumetric air flow rate on
  - * pressure loss at the cyclone
  - * degree of separation
  - * separation function and separation size (with suitable analysis device)
- comparison of pressure loss and degree of separation with theoretically calculated values

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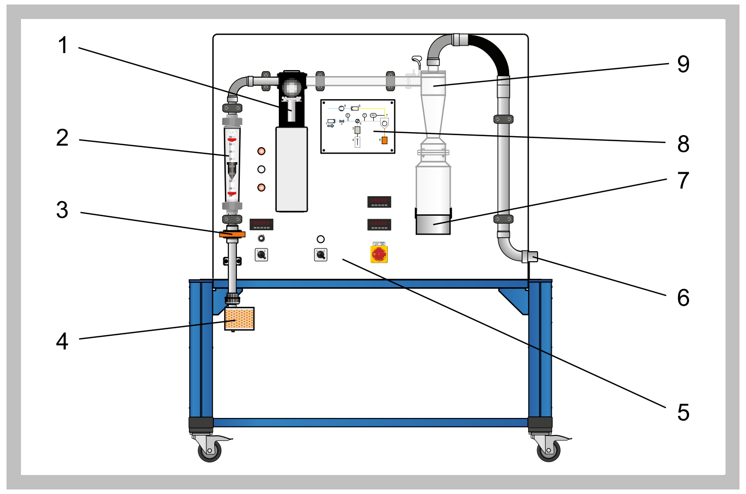
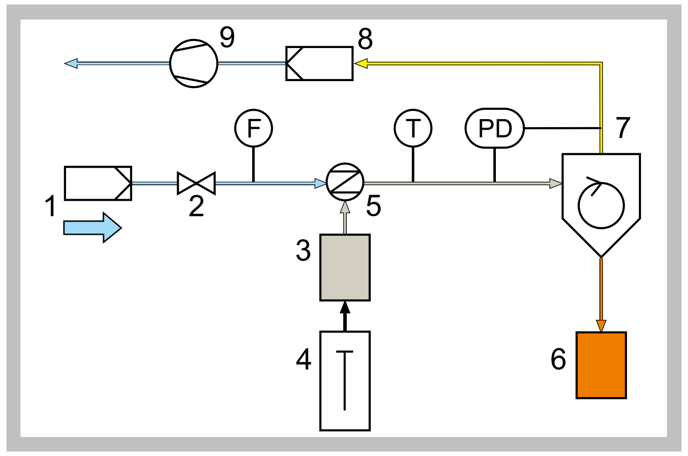
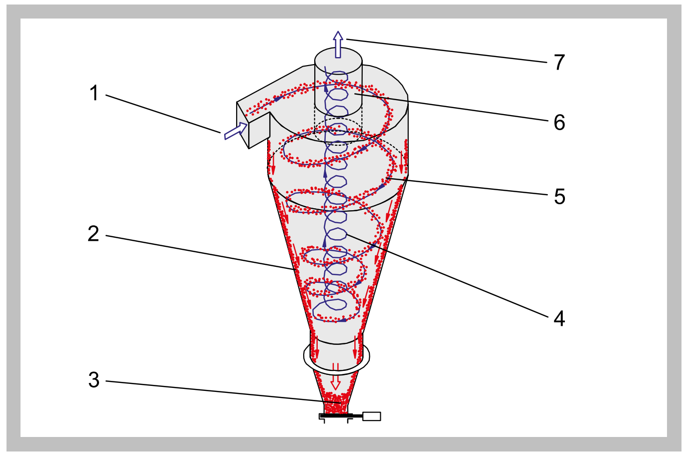
CE 235 Gas Cyclone



1 disperser with feed material tank and transport unit, 2 flow meter, 3 valve (air flow rate), 4 air inlet with filter, 5 displays and controls, 6 connection for fan, 7 coarse material tank, 8 process schematic, 9 gas cyclone



1 air inlet with filter, 2 valve (air flow rate), 3 feed material tank, 4 transport unit, 5 disperser, 6 coarse material tank, 7 gas cyclone, 8 fine material filter, 9 fan; F volumetric flow rate, PD differential pressure, T temperature



Flow conditions in a gas cyclone: 1 raw gas inlet, 2 separated solid, 3 collected solids, 4 secondary vortex, 5 primary vortex, 6 immersion tube, 7 cleaned gas

Specification

[1] solid separation from gases with a cyclone
[2] cyclone with tangential inlet
[3] metering of feed material into the air flow with a disperser
[4] air flow generation by fan; adjustment by valve
[5] tanks for feed material and coarse material
[6] 1 filter at air inlet and 1 filter for fine material at air outlet
[7] recording of differential pressure, volumetric air flow rate and temperature

Technical Data

Cyclone
- height: approx. 250mm
- diameter: approx. 80mm
- immersion tube diameter: approx. 30mm

Fan
- volumetric flow rate: max. 600m³/h
- power consumption: approx. 3600W

Tanks
- feed material: 15mL
- coarse material: 700mL

Measuring ranges
- cyclone differential pressure: 0...100mbar
- volumetric flow rate (air): 10...100m³/h
- temperature: 0...60°C

Dimensions and Weight

LxWxH: 1520x790x1800mm (trainer)
Weight: approx. 160kg (trainer)
LxWxH: 660x510x880mm (fan)
Weight: approx. 33kg (fan)

Required for Operation

230V, 50Hz, 1 phase

Scope of Delivery

1 trainer
1 fan
1 packing unit of quartz powder (0...0,16mm; 25kg)
1 filling aid for disperser
1 set of instructional material

Order Details

083.23500 CE 235 Gas Cyclone

CE 225 *Hydrocyclone*

*** Solid separation with a hydrocyclone**

*** Optimum observation of processes through transparent materials**

*** Practical experiments on a laboratory scale**

Technical Description

Hydrocyclones can be used to separate solids suspended in liquids. In CE 225, the suspension is prepared in a tank. A pump delivers the suspension into the tangential inlet of the cyclone. In the cyclone a downward primary vortex is created. The downward taper causes the vortex to reverse. In the middle it moves as a secondary vortex back up towards the immersion tube, where the suspension emerges from the cyclone, having lost the coarse material in it. Inside the cyclone an air core is formed. The centrifugal forces cause the coarser solid particles in the primary vortex to be enriched. They are discharged via the bottom flow at the apex nozzle. It is mainly the fine material that is discharged from the top.

The flow rate in the inlet is adjusted by a valve in a bypass and measured with an electromagnetic flow meter. Sampling points are installed at the bottom and top flow. The flow rates in them can be determined by means of a bucket and a stopwatch. To determine the solid concentration, a balance and a drying chamber are recommended. Using a suitable analysis device (such as a diffraction spectrometer), a separation function can be produced and the separation size determined. Quartz powder and diatomite are recommended for use as the solid.

The trainer was developed in cooperation with the **Department of Mechanical Process Engineering at Anhalt University of Applied Sciences**.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- fundamental principle and the method of operation of a hydrocyclone
- solid mass flow rate in feed, top and bottom flow
- liquid mass flow rate in feed, top and bottom flow
- characteristic values for sharpness of separation
- pressure loss at the cyclone dependent on the feed flow rate
- influence of solids density on characteristic values and pressure loss

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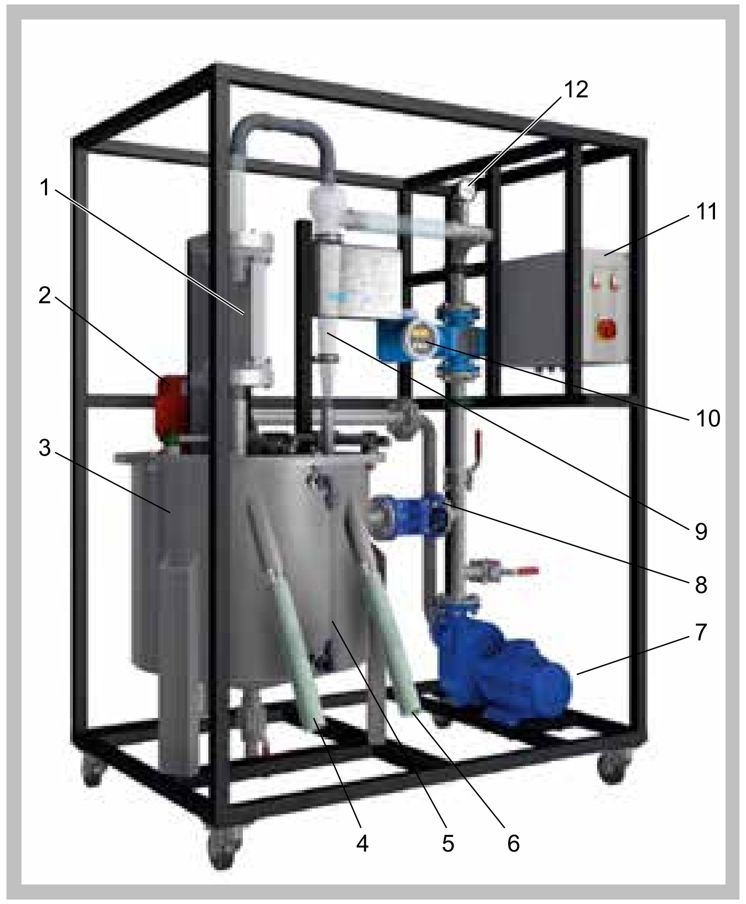
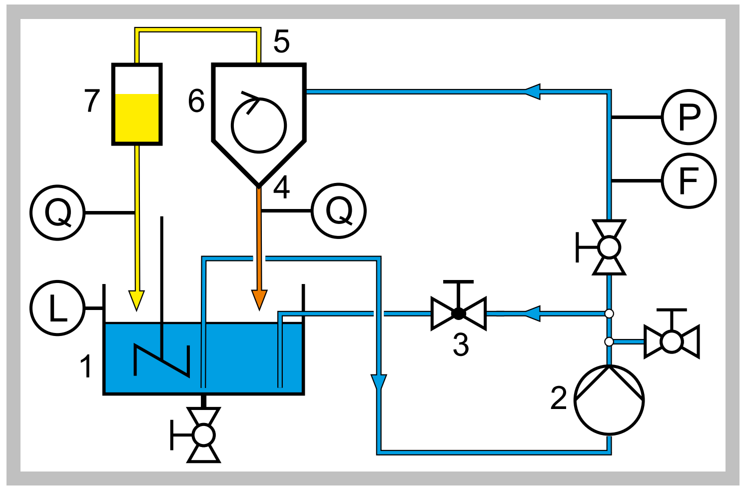
CE 225 *Hydrocyclone*



1 tank for observation of top flow, 2 stirring machine, 3 stirred tank, 4 top flow sampling point, 5 level indicator, 6 bottom flow sampling point, 7 pump, 8 valve in bypass, 9 hydrocyclone, 10 flow meter, 11 switch box, 12 manometer



1 stirred tank, 2 pump, 3 valve in bypass, 4 bottom flow, 5 top flow, 6 hydrocyclone,
7 tank for observation of top flow;
F flow meter, P manometer, L level indicator, Q sampling point

Specification

[1] solid separation from liquids with a hydrocyclone
[2] hydrocyclone with tangential inlet
[3] stirred tank for preparation of suspensions
[4] centrifugal pump to deliver the suspension
[5] adjustment of flow rate by valve in bypass
[6] electromagnetic flow meter at inlet
[7] sampling points on the top and bottom flow to determine the flow rates and solid concentrations
[8] manometer to determine the pressure loss at the cyclone

Technical Data

Cyclone
- height: 710mm
- diameter: 114mm
- immersion tube diameter: 40mm

Stirred tank
- capacity: 200L
- material: stainless steel

Top flow tank
- capacity: 5L
- material: PMMA

Pump
- max. flow rate: 400L/min
- max. head: 30m

Measuring ranges
- pressure: 0...4bar
- flow rate: 0...200L/min

Dimensions and Weight

LxWxH: 1500x1000x2050mm
Weight: approx. 390kg

Required for Operation

230V, 60Hz, 3 phases or 400V, 50/60Hz, 3 phases

Scope of Delivery

1 trainer
7 apex nozzles
1 hose
2 buckets
1 measuring cup
1 shovel
1 stopwatch
1 set of tools
25kg quartz powder
20kg diatomite
1 set of instructional material

Order Details

083.22500 CE 225 Hydrocyclone

BASIC KNOWLEDGE

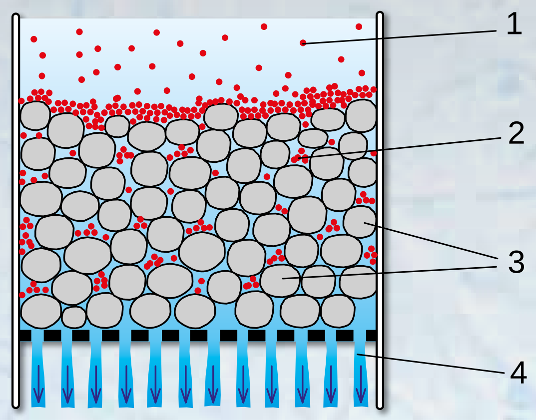
FILTRATION

During filtration, solid particles are separated off by a filter medium from a flowing suspension. Suspensions contain insoluble solids finely distributed in a liquid. Usable filter media are sieves, cloths, papers or bulk solids.

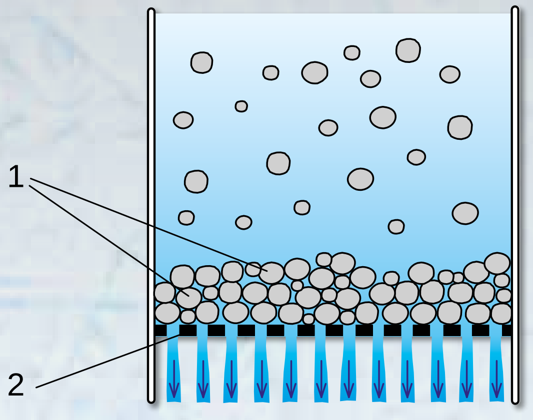
The filter medium must be as permeable to the liquid and as impermeable to the solid material as possible. The largely solid-free liquid emerging from the filter is termed the filtrate.

A fundamental distinction is made between depth filtration and cake filtration:

In **depth filtration,** the solid particles are separated inside a filter medium layer. The filter medium layer may be composed of larger grains (bulk) or of fibres. The solid particles are smaller than the pore width of the filter medium. They penetrate through the pores into the filter medium, where they are captured. Over time, the pores become more and more filled with the separated solid. This increasing loading of the filter is identifiable by a rising pressure loss. When a certain maximum pressure loss has been reached and the capacity of the filter exhausted, the filter medium layer must be replaced or cleaned. Cleaning is usually carried out by way of back-flushing. Depth filtration is used mainly in water treatment, but also in the clarification of other liquids, such as beverages.



Depth filtration:
***1** particles in suspension inlet, **2** separated particles*
***3** filter medium layer, **4** filtrate*



Cake filtration:
***1** filter cake made of separated particles*
***2** filter medium (sieve)*

In **cake filtration,** only one filter medium (sieve, cloth, filter paper) is present at the start of filtration. The pore width of the filter medium is less than the particle size of the solid. A growing filter cake made up of the separated particles thus forms over time on the filter medium. As a result, the pressure loss also increases and the flow rate decreases. For this reason the filter cake must be removed after a certain time. A distinction can be made between discontinuous and continuous filtration. In discontinuous filtration apparatus, such as Nutsche Filters, the filtration process must be interrupted in order to remove the filter cake. An example of a continuous filter is the drum cell filter. It permits the filter cake to be removed while filtration is in progress. The desired product of a filtration may be the filtrate or the filter cake. Often the filter cake is rinsed and dried following filtering.

CE 116 Cake and Depth Filtration

*** Cake and depth filtration with different suspensions and filter medium layers**

Technical Description

With CE 116 the processes in depth filtration and cake filtration can be observed and investigated. The suspension (water and diatomite as the solid) flows from the hopper into the top of the filter element, where the solids are separated off. The filtrate flows through a flow meter into the drain. The filter element has a porous filter medium at the bottom. In cake filtration, the filter medium provides the foundation for build-up of the filter cake. In depth filtration, the filter medium supports the bulk solids (filter medium layer; gravel). Twin tube manometers measure the pressure loss over the filter element.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- fundamentals of filtration: Darcy's equation
- depth filtration with different bulk solids and suspensions
- cake filtration with different suspensions
- identification of characteristic filtration values

Specification

[1] fundamentals of cake and depth filtration
[2] filter element with sintered filter medium on its bottom to capture the particles
[3] pressure loss measurement with twin tube manometers
[4] height-adjustable filler hopper made of DURAN glass
[5] flow meter with needle valve for adjustment

Technical Data

Filter element
- filter chamber height: 85mm
- inside diameter: approx. 37mm
- cross-sectional area: approx. 11cm²
- tube material: DURAN glass

Filter medium, sintered filter SIKA 100
- pore size: 100µm
- thickness: 2mm
- material: sintered metal

Measuring ranges
- flow rate: 40...360mL/min
- pressure: 2x 0...500mmWC
- temperature: -10...100°C
- measuring cups
  1x 1000mL, scale division: 10mL
  1x 100mL, scale division: 2mL

Dimensions and Weight

LxWxH: 450x410x1040mm
Weight: approx. 30kg

Required for Operation

Drain recommended,
balance to register the filtrate quantity

Scope of Delivery

1 experimental unit
2 measuring cups
1 stopwatch
1 thermometer
1kg sand (1...2mm)
2kg diatomite
1 set of instructional material

Order Details

083.11600 CE 116 Cake and Depth Filtration

CE 117 Flow through Particle Layers

*** Experiments in the fundamentals of fluid mechanics on particle layers**

*** Flow through fixed beds**

*** Flow through fluidised beds**

*** Pressure loss in fixed beds and fluidised beds**

Technical Description

Flow through particle layers is widely encountered in process engineering. In reactors, fixed and fluidised beds are subjected to through-flow by liquids and gases. The separation of solids from suspensions by cake and depth filtration is another area of application.

With CE 117 the fluid mechanic principles involved in flow through fixed beds and fluidised beds can be investigated. For the purpose, a fillable test tank made of glass is provided, through which water can be made to flow from both ends. A sintered-metal plate serves as the base for bulk solids.

Water from the laboratory water connection flows into the test tank. To investigate flow through fixed beds, the water enters the test tank from the top. It flows through the fixed bed and the sintered-metal plate and passes by way of a distributor to the outlet.

The experimental set-up can be modified by means of quick-release couplings. This also enables the flow through the test tank to be reversed and fluidised beds to be investigated. The water flows upwards through the porous sintered-metal plate and the fixed bed. If the velocity of the water is less than the so-called fluidisation velocity, the flow merely passes through the fixed bed. At higher velocities a fluidised bed is formed. The water flows from the head of the test tank into an expansion tank. From there it flows into the outlet.

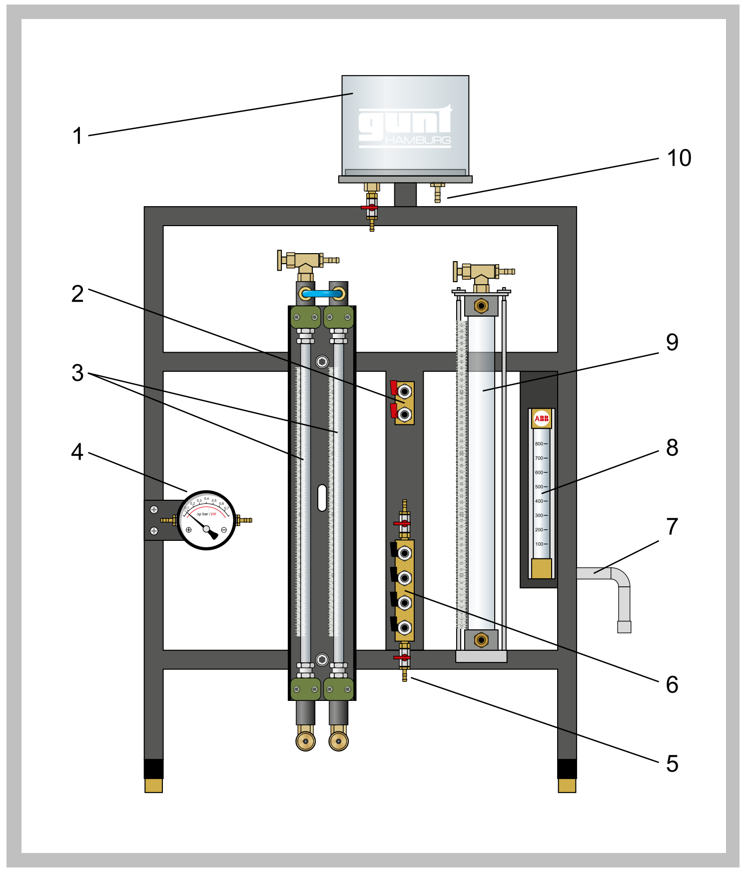
Regardless of the specific set-up, the flow rate is adjusted by a valve and indicated by a flow meter. To determine the pressure loss via the fixed bed or fluidised bed, two manometers with differing measuring ranges are provided. The desired manometer is selected by way of valves.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

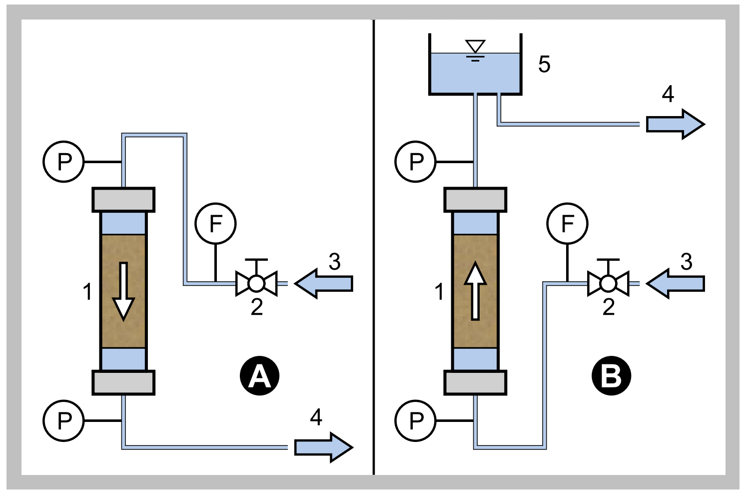
Learning Objectives / Experiments

- learning the fundamentals of flow through fixed beds and fluidised beds (Darcy)
- observation of the fluidisation process
- pressure loss dependent on the flow rate, type, particle size and height of the bulk solid
- determination of the fluidisation velocity and comparison with theoretically calculated values
- verification of Carman-Kozeny equation

CE 117 Flow through Particle Layers



1 expansion tank, 2 inlet distributor, 3 tube manometer, 4 manometer, 5 outlet,
6 distributor for pressure measurement, 7 inlet, 8 flow meter, 9 test tank, 10 outlet



Process schematic for the investigation of fixed beds (A) res. fluidised beds (B):
1 test tank (particle layer), 2 valve (flow rate), 3 inlet, 4 outlet, 5 expansion tank;
P pressure, F flow rate

Specification

[1] investigation of the properties of fixed and fluidised beds subjected to liquid flow
[2] glass test tank with sintered filter medium on its base
[3] test tank removable for filling
[4] downward flow to investigate fixed beds
[5] upward flow to investigate fluidised beds
[6] flow meter with valve for adjustment
[7] 2 manometers with differing measuring ranges to measure pressure loss through the test tank
[8] steel rule to measure the height of the fixed or fluidised bed

Technical Data

Test tanks
- length: 510mm
- inside diameter: approx. 37mm
- material: DURAN glass

Filter medium
- thickness: 2mm
- material: sintered metal

Expansion tank
- capacity: approx. 4500mL
- material: PVC

Measuring ranges
- flow rate: 60...820mL/min
- tube manometers: 2x 0...500mmWC
- manometer: 0...250mbar
- steel rule: 10...500mm

Dimensions and Weight

LxWxH: 690x410x1150mm
Weight: approx. 26kg

Required for Operation

Water connection: approx. 1L/min
Drain recommended

Scope of Delivery

1 experimental unit
0,5kg sand (1...2mm)
0,5kg glass-shot beads (180...300µm)
1,0kg glass-shot beads (420...590µm)
1 set of instructional material

Order Details

083.11700 CE 117 Flow through Particle Layers

CE 287 Plate and Frame Filter Press

*** Separation of solids from suspensions with a plate and frame filter press**

*** Discontinuous cake filtration**

*** Practical experiments on a laboratory scale**

Technical Description

Plate and frame filter presses are used in the beverage industry, for example, to clarify intermediate products.

A suspension of diatomite and water (recommended) is prepared in a tank. A pump ensures that the solid remains suspended and does not settle. The pump delivers the suspension into the individual separating chambers of the plate and frame filter press. A separating chamber is formed by one filter frame and two filter plates. The filter plates are grooved and covered over with filter cloths. The filtrate passes through the filter cloth and flows via the grooves in the plates into a collecting pipe. The filtrate exits the plate and frame filter press through the collecting pipe and is collected in the filtrate tank. The solid material is separated off at the filter cloth, where it forms a growing filter cake. As the filter cake becomes thicker, its flow resistance also increases. When the separating chamber is full, or a maximum pressure difference has been reached, the filtration process is ended. The plates and frames of the plate and frame filter press are pulled apart. The filter cake can be removed. For the next filtration the plates and frames must be pushed back together. A spindle is used to press them together. The press forces ensure that the suspension does not leak from the contact points between the plates and the frames, but is forced through the filter cloth.

The flow rate through the plate and frame filter press is adjusted by a valve. The pressure occurring during filtration is indicated on a manometer. The filtrate tank is scaled. This means a stopwatch can be used to measure the flow rate. An included opacimeter allows the solid concentration of the filtrate to be determined. A drying chamber is recommended for evaluation of the experiments.

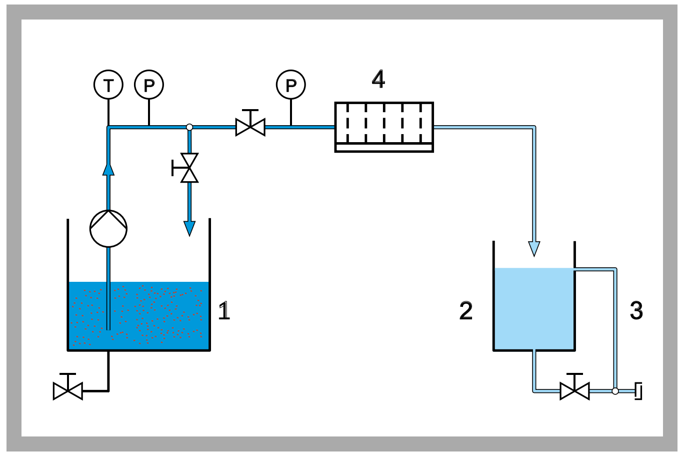
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

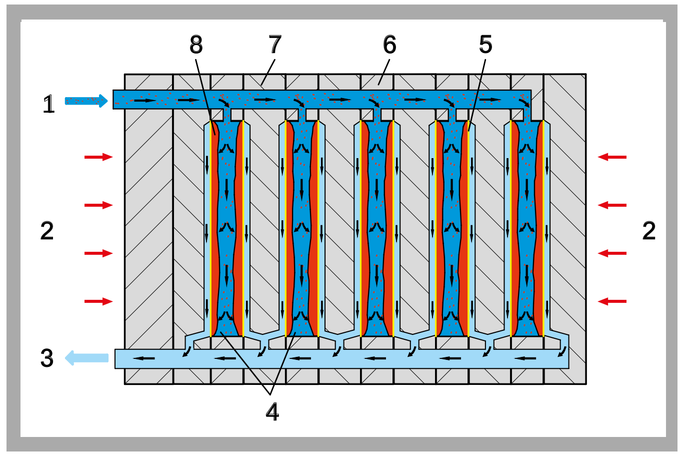
- learning the fundamental principle and method of operation of a plate and frame filter press
- production of a suspension
- removal of the filter cake
- insertion of the filter cloth
- fundamentals of cake filtration: Darcy's equation
- variation in time of filtrate quantity and solid concentration in filtrate
- mass of filter cake dependent on filtrate quantity

CE 287 Plate and Frame Filter Press

1 switch box with controls, 2 suspension tank, 3 filtrate tank outlet and overflow, 4 filtrate tank, 5 spindle, 6 plate and frame filter press



1 tank with pump, 2 filtrate tank, 3 overflow, 4 plate and frame filter press; T temperature, P pressure



Fundamental principle of a plate and frame filter press: 1 suspension inlet, 2 press forces, 3 filtrate outlet, 4 separating chambers, 5 filter cloth, 6 filter frame, 7 filter plate, 8 filter cake

Specification

[1] plate and frame filter press for discontinuous cake filtration
[2] HDPE tank to produce a suspension
[3] centrifugal pump to deliver the suspension to the plate and frame filter press
[4] plate and frame filter press with 10 opening separating chambers for removal of the filter cake
[5] PMMA tank with level scale for filtrate
[6] adjustment of suspension flow rate by valve
[7] thermometer and manometer in inlet
[8] portable opacimeter to measure the solid concentration in the filtrate

Technical Data

Plate and frame filter press
- filter area: approx. 0,72m²
- working pressure: approx. 0,4...2,5bar

Centrifugal pump (submersible pump)
- max. flow rate: 4,5m³/h
- max. head: 45m

Tanks
- suspension tank: 200L
- filtrate: 20L

Measuring ranges
- pressure: 0...4bar
- temperature: 0...60°C

Dimensions and Weight

LxWxH: 1900x790x1900mm
Weight: approx. 190kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase
Water connection

Scope of Delivery

1 trainer
1 portable opacimeter
1 stopwatch
1 set of filter cloths
2 hoses
20kg diatomite
1 set of dust masks
1 set of instructional material

Order Details

083.28700 CE 287 Plate and Frame Filter Press

CE 283 Drum Cell Filter

*** Separation of solids from suspensions with a drum cell filter**

*** Continuous removal of filter cake**

*** Practical experiments on a laboratory scale**

Technical Description

Drum cell filters can be used to separate solids continuously from suspensions.

The suspension unit CE 285 produces a suspension of diatomite and water. A pump conveys the suspension into the suspension tank of the drum cell filter. A stirrer keeps the solid particles in the suspension suspended. Part of the rotating drum dips into the suspension. The jacket of the drum is perforated and covered over with a filter cloth. The drum is divided into cells. Each cell is joined by a hollow shaft to a vacuum line. The vacuum sucks filtrate through the filter cloth into the drum. From there it is carried in a collector tank which is under vacuum. The solid is separated off at the filter cloth. Consequently, a filter cake which steadily grows in the direction of rotation is created on the immersed part of the drum. When the filter cake is drawn out of the suspension by the rotating motion, it is drained of water by the applied vacuum. A scraper scrapes the filter cake off of the drum before the drum dips back into the suspension. Compressed air can also be used to remove the filter cake. The filter cake drops into a collector tank.

The flow rate of the supplied suspension is adjusted on the suspension unit. The level in the suspension tank of the drum cell filter can be adjusted by way of an adjustable overflow. The applied negative pressure is indicated by a manometer on the vacuum tank. The rotation speed of the drum is infinitely variable.

Compressed air and vacuum connections are required to operate the trainer.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- learning the basic principle and method of operation of a drum cell filter
- fundamentals of cake filtration: Darcy’s equation
- variation in time of filtrate quantity, filter cake mass and thickness
- filter cake mass and thickness dependent on filtrate quantity, negative pressure and drum speed

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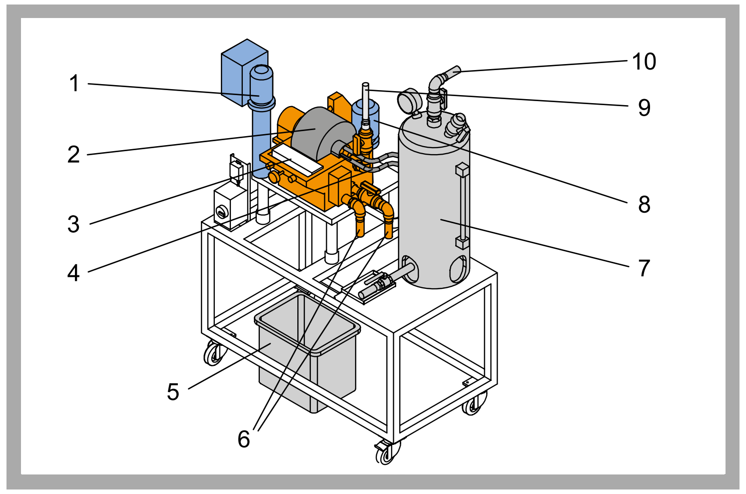
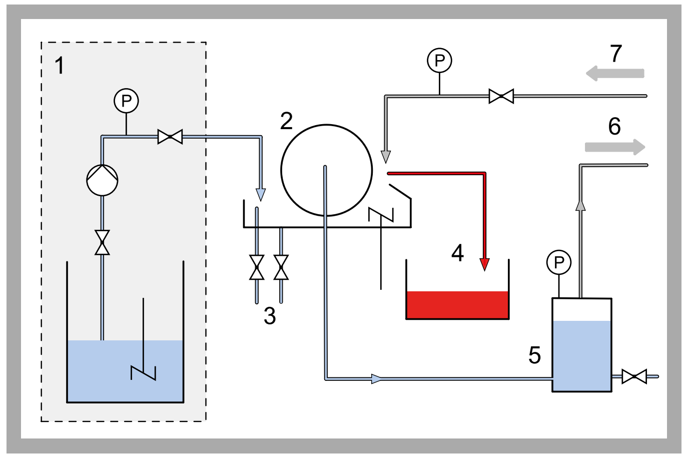
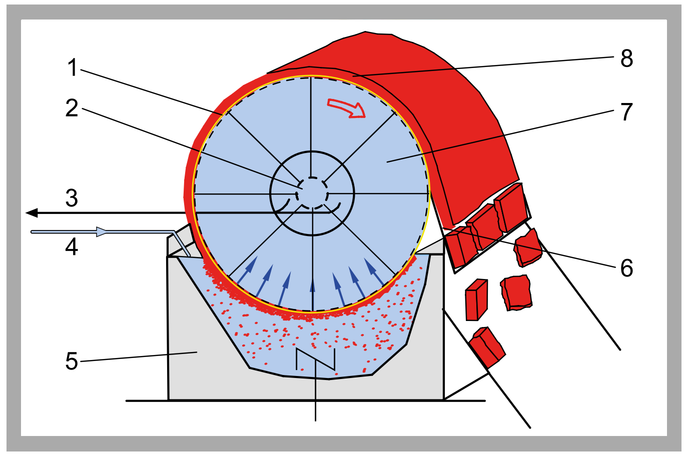
CE 283 Drum Cell Filter



1 motor (drum), 2 drum, 3 scraper, 4 filtrate vacuum lines, 5 filter cake collector tank, 6 suspension tank overflow and outlet, 7 filtrate vacuum tank, 8 motor (stirrer), 9 suspension inlet, 10 vacuum connection



1 suspension unit (CE 285), 2 drum cell filter, 3 suspension tank overflow and outlet, 4 filter cake collector tank, 5 filtrate vacuum tank, 6 vacuum connection, 7 compressed air connection with pressure limiter; P manometer



Fundamental principle of a drum cell filter: 1 perforated drum with filter cloth, 2 hollow shaft, 3 vacuum (filtrate), 4 suspension inlet, 5 suspension tank, 6 filter cake removal, 7 cell, 8 filter cake

Specification

[1] continuous cake filtration of suspensions with a drum cell filter
[2] rotating perforated drum, partially immersed in suspension, with filter cloth
[3] vacuum inside drum to draw off filtrate and dry filter cake
[4] continuous removal of filter cake with adjustable scraper or compressed air
[5] drum speed infinitely variable
[6] plastic vacuum tank to collect filtrate
[7] suspension tank with stirrer and overflow
[8] plastic collector tank for filter cake
[9] production and transport of suspension with suspension unit CE 285

Technical Data

Drum
- filter area: approx. 0,1m²
- speed: approx. 0,1...3min^{-1}
- motor power consumption: approx. 300W

Stirrer
- speed: approx. 15min^{-1}
- motor power consumption: approx. 120W

Tanks
- filtrate vacuum tank: approx. 30L
- filter cake collector tank: approx. 30L
- suspension: approx. 3L

Measuring ranges
- vacuum tank pressure: -1...0bar
- cake remover compressed air: 0...2bar

Dimensions and Weight

LxWxH: 1400x800x1800mm
Weight: approx. 100kg

Required for Operation

230V, 60Hz/CSA, 3 phases or 400V, 50Hz, 3 phases
Vacuum and compressed air connections required
Water connection recommended

Scope of Delivery

1 drum cell filter
1 collector tanks
1 set of hoses
1 set of filter cloths
1 set of instructional material

Order Details

083.28300 CE 283 Drum Cell Filter

CE 284 *Nutsche Vacuum Filter*

*** Cake filtration with a Nutsche vacuum filter**

Technical Description

Nutsche filters are used for discontinuous cake filtration of suspensions with high solid concentrations. The suspension production unit CE 285 produces a suspension of diatomite and water and delivers it from above into the Nutsche filter. A filter bag is inserted in the Nutsche filter. A growing filter cake accumulates in the filter bag made from the separated solid material. The vacuum in the bottom section of the Nutsche filter draws filtrate through the filter cake and the filter bag. It is collected in the bottom section. After filtering, the filter cake obtained is washed with a washing liquid (water) and is dried by the applied vacuum before being removed.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- basic principle and method of operation of a Nutsche vacuum filter
- fundamentals of cake filtration: Darcy's equation
- mass and thickness of filter cake dependent on filtrate quantity

Specification

[1] Nutsche vacuum filter for discontinuous cake filtration
[2] open 2-part vessel with flange and recessed sieve base
[3] bottom section to draw in and collect filtrate
[4] top section with inserted filter bag to form filter cake
[5] polyester filter bag
[6] manometer to indicate negative pressure in bottom section
[7] 2 sight glasses to observe level in bottom section
[8] production and transport of suspension with suspension production unit CE 285

Technical Data

Vessel
- inside diameter: approx. 300mm
- capacity: approx. 55L
- permissible pressure: -1bar
- permissible temperature: -10...100°C
- material: stainless steel

Manometer
- measuring range: -1...0bar
- diameter: 160mm

Dimensions and Weight

LxWxH: 600x900x1900mm
Weight: approx. 100kg

Required for Operation

Vacuum and water connections required

Scope of Delivery

1 Nutsche vacuum filter
1 filter bag
1 set of instructional material

Order Details

083.28400 CE 284 Nutsche Vacuum Filter

CE 286 *Nutsche Pressure Filter*

*** Cake filtration with a Nutsche pressure filter**

Technical Description

Nutsche filters are used for discontinuous cake filtration of suspensions with high solid concentrations. The suspension production unit CE 285 produces a suspension of diatomite and water and delivers it from above into the Nutsche filter. In the bottom flange of the Nutsche filter is a recessed sieve base with a filter cloth. A growing filter cake accumulates on the filter cloth made from the separated solid material. The applied positive pressure in the top section of the Nutsche filter pushes the filtrate through the filter cake and the filter cloth. It is collected in the bottom section of the tank. After filtering, the filter cake obtained is washed with a washing liquid (water) and is then dried by an air flow.

Learning Objectives / Experiments

- basic principle and method of operation of a Nutsche pressure filter
- fundamentals of cake filtration: Darcy's equation
- mass and thickness of filter cake dependent on filtrate quantity

Specification

[1] Nutsche pressure filter for discontinuous cake filtration
[2] enclosed 3-part vessel with 2 flanges and 2 bumped bases
[3] bottom flange with recessed sieve base and PP filter cloth
[4] bottom section of vessel to collect filtrate
[5] centre section to form filter cake
[6] top section removable to remove filter cake
[7] maintenance and pressure control unit to adjust positive pressure in centre and top section
[8] 2 manometers to indicate pressure upstream and downstream of filter
[9] 2 sight glasses to observe level in bottom section
[10] production and transport of suspension with suspension production unit CE 285

Technical Data

Vessel
- inside diameter: approx. 300mm
- capacity: approx. 75L
- permissible pressure: -1...10bar
- permissible temperature: -10...100°C
- material: stainless steel

Measuring ranges
- 2x manometers (D=160mm): 0...4bar
- 1x maintenance and pressure control unit: 0,5...8,5bar

Dimensions and Weight

LxWxH: 600x900x1900mm
Weight: approx. 120kg

Required for Operation

Compressed air and water connections required

Scope of Delivery

1 Nutsche pressure filter
1 filter cloth
1 set of instructional material

Order Details

083.28600 CE 286 Nutsche Pressure Filter

CE 285 Suspension Production Unit

* Supply unit for experimental filtration units CE 283, CE 284, CE 286

Technical Description

CE 285 provides the experimental filtration units with a suspension of diatomite and water (recommended). It is prepared in the stirred tank. The stirrer ensures that the solid remains suspended and does not settle. An eccentric screw pump delivers the suspension to the connected experimental unit. The pump rotor is made of stainless steel. It runs inside an elastomer housing. A manometer indicates the delivery pressure. A pressure cut-out switch stops the pump if the pressure is too high. A temperature transducer protects the pump from running dry. The speed of the pump can be adjusted on a potentiometer. The stirred tank features a level indicator and three flow impeders. All necessary connecting elements are supplied to connect the supply unit to the relevant experimental filtration unit.

Scope of Delivery

1 suspension production unit
1 packing unit of diatomite
1 set of hoses
1 set of instructional material

Specification

[1] supply unit to produce and deliver suspensions for experimental filtration units
[2] stirred tank with lid and stirring machine to prepare a suspension
[3] eccentric screw pump, with pressure cut-out switch, dry-running protection and adjustable speed, to deliver the suspension

Technical Data

Tank: 200L, stainless steel
Stirring machine
- power consumption: 180W
- speed: 1000min^{-1} (constant)

Pump
- max. head: 50m
- max. flow rate: approx. 230L/h

Manometer measuring range: 0...10bar

Dimensions and Weight

LxWxH: 1850x850x1450mm
Weight: approx. 220kg

Required for Operation

400V, 50Hz, 3 phases or 230V, 60Hz/CSA, 3 phases

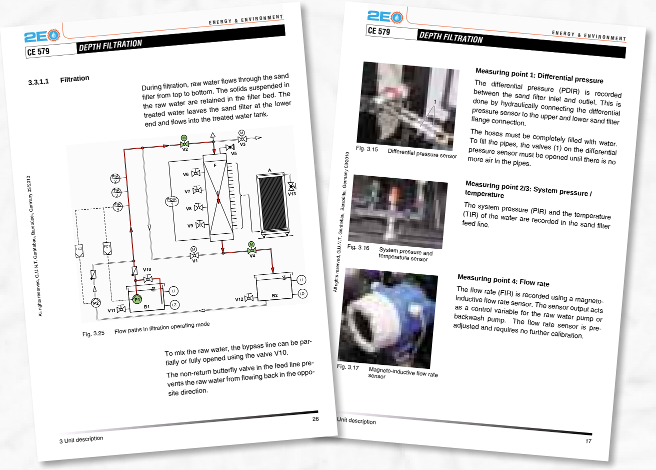
Order Details

083.28500 CE 285 Suspension Production Unit

CE 579 DEPTH FILTRATION

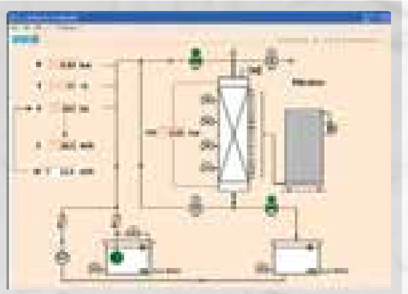
The ideal way to teach and learn about depth filtration in all its aspects

- filtration and backwash
- comprehensive range of instrumentation
- manometer panel to measure the pressures in the filter bed
- state-of-the-art software with control functions and data acquisition

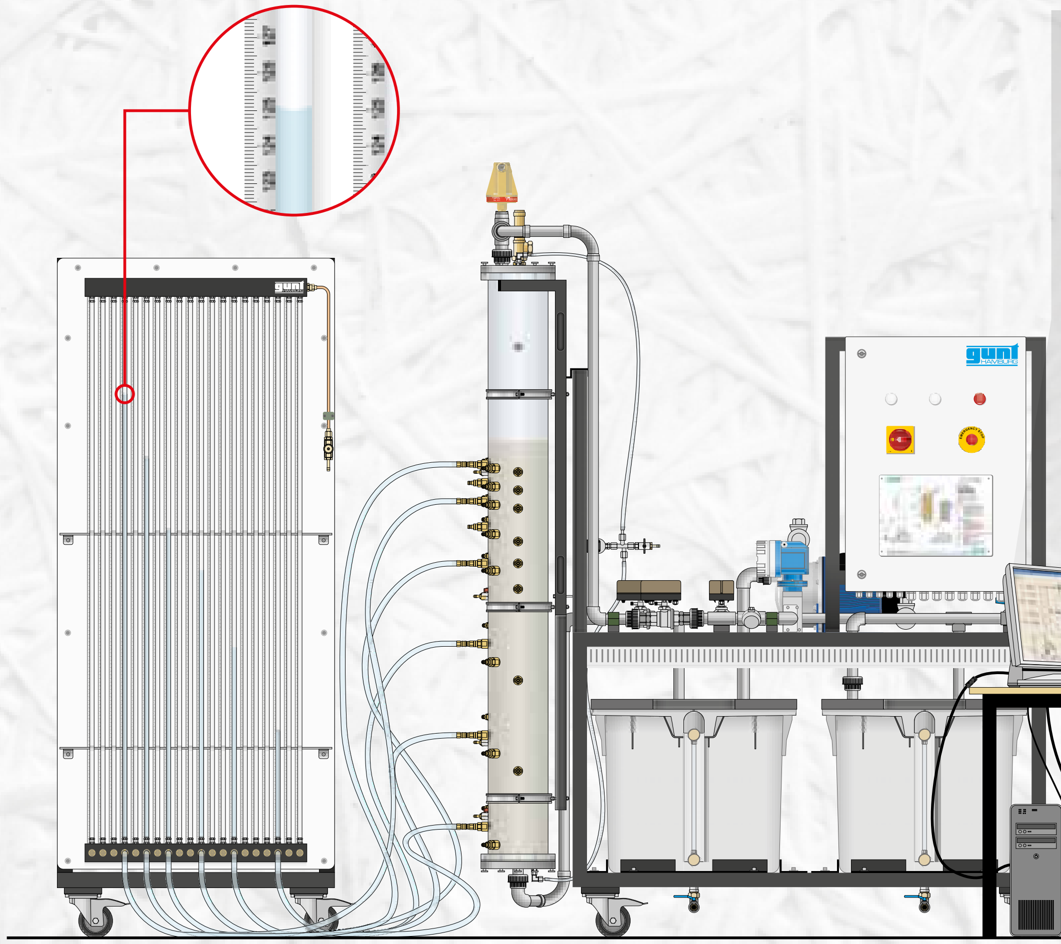


The well-structured instructional material is delivered as paper printouts in a folder and additionally as PDF files on a CD.

Use of high quality components: Magneto-inductive flow rate sensor, backwash pump and ball valves with electric drive



GUNT software



Manometer panel

Trainer

CE 579 Depth Filtration

The illustration shows: manometer panel (left) and trainer (right)

*** Removal of solids by depth filtration (sand filter)**
*** Pressure loss: plotting of Micheau diagrams**
*** Backwash of sand filters**

Technical Description

Depth filtration with sand filters is a key unit operation in water treatment. CE 579 enables this process to be demonstrated.

Raw water contaminated with solids is pumped from above into a sand filter. The solids are captured and retained as the raw water flows through the filter bed. The water itself passes through the filter bed and emerges at the bottom end of the sand filter. The treated water (filtrate) flows into a tank. Over time, more and more solids are deposited in the filter bed which increases its flow resistance. This process is detectable by the increasing pressure loss between the sand filter inlet and outlet. The flow through the sand filter decreases. Backwashing with treated water cleans the filter bed and reduces the pressure loss again.

The sand filter is equipped with a differential pressure gauge. There are also several pressure measuring points along the filter bed. The pressures are transmitted to tube manometers via hoses and displayed there as water columns. This can be used to plot Micheau diagrams. The flow rate, temperature, differential pressure and system pressure are measured. The flow velocity in the filter bed (filter velocity) can be adjusted. Samples can be taken at all relevant points.

A software program is provided to control the operating states and measure data. A process schematic shows the current operating states of the individual components and the measured data. E.g. diatomite can be used to produce the raw water.

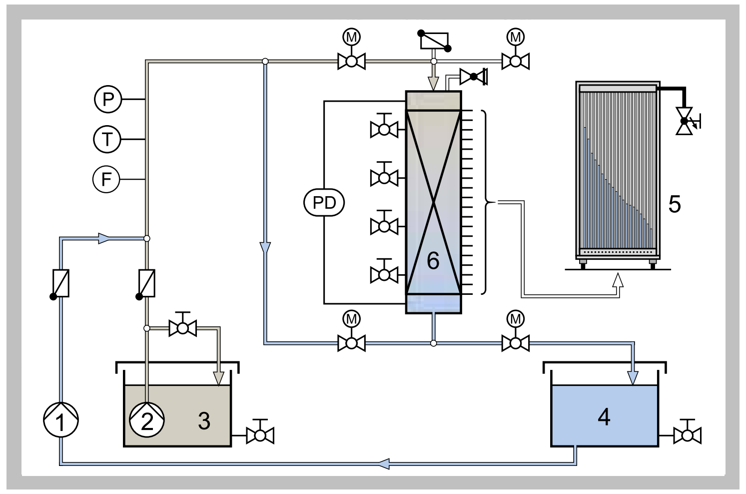
The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- learning the fundamental principle of depth filtration by sand filters
- observation of the pressure conditions in a filter bed
- determination of pressure losses
- plotting of Micheau diagrams
- principle of backwash

CE 579 Depth Filtration

1 treated water tank, 2 raw water tank, 3 raw water pump, 4 switch cabinet, 5 bachwash pump, 6 electromagnetic flow rate sensor, 7 temperature sensor, 8 ball valves with electric drive, 9 bleed valve, 10 sand filter



1 backwash pump, 2 raw water pump, 3 raw water, 4 treated water (filtrate), 5 manometer panel, 6 sand filter; F flow rate, P system pressure, PD differential pressure, T temperature

Specification

[1] depth filtration with sand filter
[2] sand filter backwash possible
[3] 20 tube manometers to measure the pressures in the filter bed
[4] plotting of Micheau diagrams
[5] raw water and backwash pump
[6] electromagnetic flow rate sensor
[7] 4 ball valves with electric drive
[8] measurement of flow rate, differential pressure, system pressure and temperature
[9] filter velocity adjustable
[10] GUNT software with control functions and data acquisition via USB under Windows Vista or Windows 7

Technical Data

Sand filter
- outer diameter: 200mm
- inside diameter: 150mm
- height: 1660mm

Raw water pump
- max. flow rate: 13m³/h
- max. head: 10m

Backwash pump
- max. flow rate: 3m³/h
- max. head: 37m

Tanks for raw water and treated water
- capacity: each 180L

Measuring ranges
- flow rate: 0...1300L/h
- tube manometers: 20x 0...1500mmWC
- differential pressure: -1...1bar
- system pressure: 0...4bar
- temperature: 0...100°C
- filter velocity: 0...70m/h

Dimensions and Weight

LxWxH: 1590x900x2190mm (trainer)
LxWxH: 750x640x1900mm (manometer panel)
Total weight: approx. 250kg

Required for Operation

230V, 50/60Hz, 1 phase or 230V, 60Hz/CSA, 3 phases
Water connection, drainage

Scope of Delivery

1 trainer
1 manometer panel
1 set of hoses
1 packing unit of gravel
1 packing unit of diatomite
1 GUNT software CD + USB cable
1 set of instructional material

Order Details

083.57900 CE 579 Depth Filtration

BASIC KNOWLEDGE

COMMINUTION

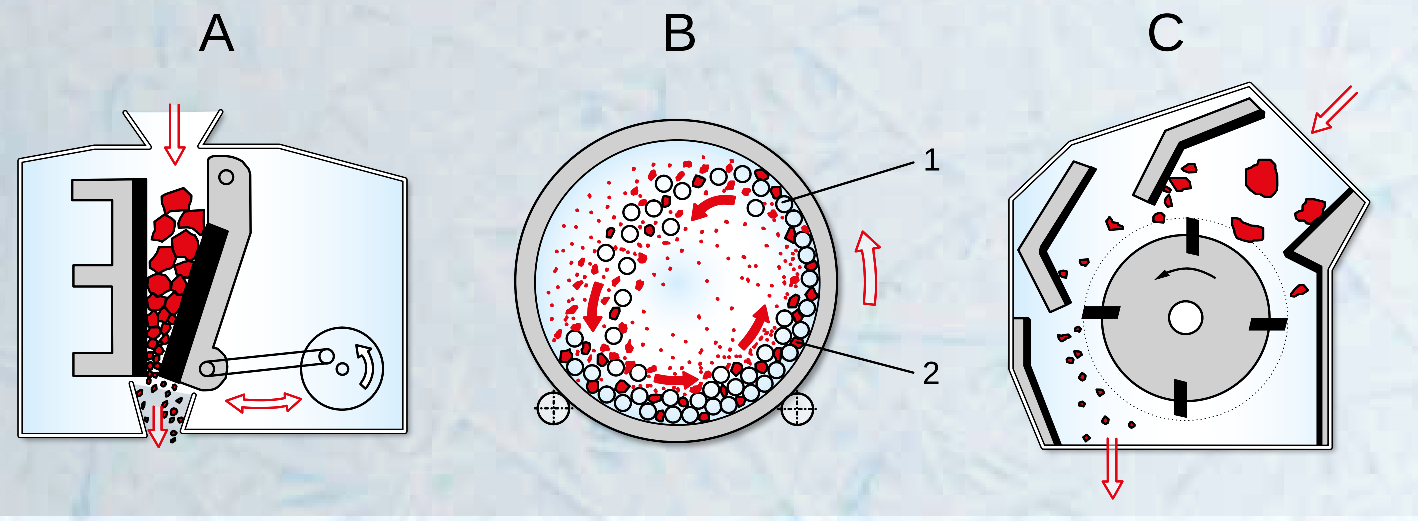
Comminution alters the particle size and shape and the surfaces of solids. Virtually all solids must be comminuted when being mined or processed.

The comminution of solids can be used for a variety of purposes:

Creating intermediate or end products with specific particle sizes
For many processes applied to solids, specific particle sizes are required in order to create a desired product. For example, thermoplastic input products must be delivered in the form of pellets of a specific size. That is the form in which they can best be melted and formed.

Enlargement of the surface
Chemical reactions take place more rapidly when the surface areas of the reacting materials are larger. For example, fine milled coal dust burns explosively, while large pieces of coal burn slowly. Likewise, salts are dissolved more quickly in liquids the smaller their particle size.

Recovery of usable materials from solid compounds
Waste materials, mineral and plant raw materials consist of different components. In order to expose the usable materials for further processing, the raw materials must be comminuted. The comminution process is often followed by a sorting process to separate out the usable material. A key example is the recovery of iron ores from rock compounds.



Examples of comminution machines:
***A** jaw crusher, **B** ball mill, **C** impact crusher, **1** milling balls, **2** material to be milled*

The result of a comminution depends primarily on the method of stress loading applied. In most comminution machines stress is applied between two solid surfaces or by impact:

Stress between solid surfaces
The particles are between two surfaces which are moving relative to each other. In the process, the particles are subjected to stress, such as by pressure, shearing, shock impact or cutting. This type of stress loading occurs in the case of jaw crushers and roller or ball mills for example.

Impact stress
The particles either impact at high speed against a fixed wall or a tool moves against a free-flying particle. The comminution can also occur when two particles collide.

Typical comminution machines in which the particles are subjected to impact stress are impact crushers and hammer crushers.

CE 245 Ball Mill

*** Comminution with a ball mill**

*** Observation of the milling process**

Technical Description

Ball mills are a form of mills with grinding bodies. The drums can be opened at the front and loaded with the material to be milled (limestone is recommended) and the milling balls. The drums are mounted on a drive roller and a loose roller with adjustable spacing between the axles. At low rotation speeds the comminution is effected by the balls rolling over the material (cascade motion). At higher speeds, some balls are lifted up the wall, become detached and drop down onto the material (cataract motion). Above the critical speed, centrifugal forces ensure that no more comminution takes place. These motion states can be observed through the transparent fronts of the drums.

In order to compare the theoretical power demand with the actual, the power consumption of the drive motor is indicated on a digital display. To assess the success of the comminution, an analytical screening machine (CE 264) is recommended.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

Learning Objectives / Experiments

- cascade and cataract motion, critical speed
- theoretical and actual power demand
- degree of comminution dependent on milling time, rotation speed, ball diameter, ball filling, material to be milled

Scope of Delivery

1 ball mill, 3 milling drums, 1 set of milling balls, 1 set of instructional material

Specification

[1] comminution of solids with a ball mill
[2] 2 drums with steel jackets and transparent fronts, 1 steel drum with lifting bars
[3] 1 drive roller with adjustable speed, 1 loose roller
[4] axle spacings of rollers adjustable to accommodate different drums
[5] measurement of power consumption
[6] milling time programmable by timer

Technical Data

2 drums with borosilicate fronts
- D=100mm/185mm, capacity: approx. 1,15L/7,5L
1 drum with lifting bars
- D=185mm, capacity: approx. 7,5L
- roller diameter: approx. 50mm
Measuring ranges
- power consumption: 0...200W
- roller speed: 0...300min^{-1}
1 set of milling balls: D=5/10/15mm

Dimensions and Weight

LxWxH: 600x520x460mm
Weight: approx. 76kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Order Details

083.24500 CE 245 Ball Mill

BASIC KNOWLEDGE

MIXING

Mixing is the opposite of separating. The materials being mixed may be gaseous, liquid or solid.

During the **mixing of solids**, the processed substances are powderous or granular. The objective is usually to create mixtures as homogeneous as possible. This is illustrated particularly clearly by the example of the manufacture of tablets: inadequate mixing of the starting substances would result in differing agent compositions in the tablets.

During **stirring,** the continuous phase is liquid. A liquid, gas or solid is mixed into a liquid.

Key applications of stirring are:

- **Mixing of miscible liquids**
  The purpose is to balance out differences in concentration and temperature. Moreover, the course of the reaction in the mixture can also be controlled, as the reaction speed is dependent on the mix quality of the reaction partners.

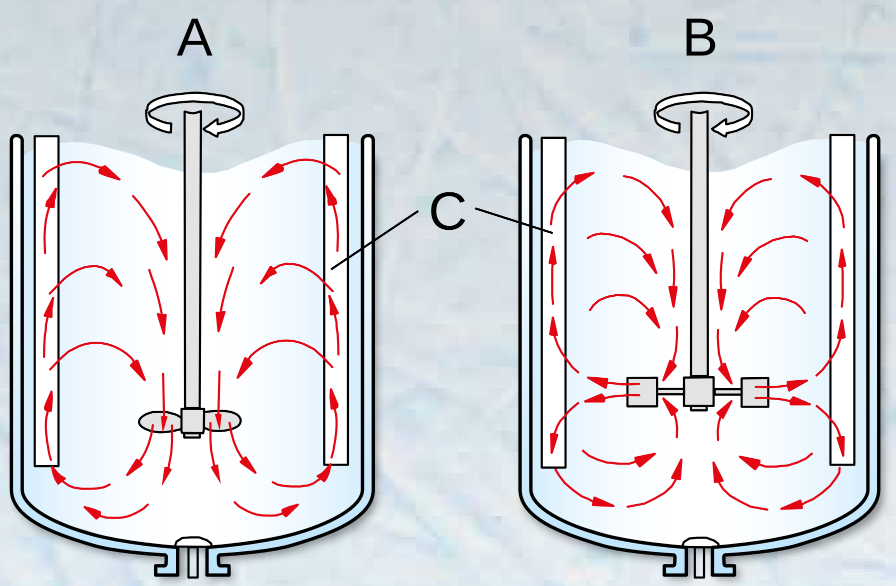
- **Mixing of immiscible liquids (emulsifying)**
  The liquid phase to be dispersed is in droplet form in the other liquid phase. This is true in the case of cosmetic creams and lotions for example.

- **Dispersion of soluble solids in liquids**
  The solid is dispersed in the liquid, and in the process is disintegrated into atoms, molecules or ions. The solid is no longer identifiable as such after being dissolved. Stirring accelerates the dissolution process.

- **Dispersion of an insoluble solid in a liquid (suspension)**
  The resultant suspensions tend to segregate, meaning that over time the solid particles would sink. Stable suspensions are created only at particle sizes below 1µm. An example is to be found in the case of paints, in which colour pigment particles are suspended in resins.

- **Gasification of liquids**
  Gas bubbles in the liquid are finely distributed by means of a perforated plate or other forms of injectors. One application is the precipitation of iron oxides by injection of air in waste water treatment.

Stirrers of a wide variety of forms are used, depending on the application. They can be roughly differentiated according to the flow field they create. Accordingly, there are axial, radial and tangential conveying stirrers. Flow impeders or buffers are employed to prevent the entire vessel contents rotating along with the stirrer.



Typical flow fields in stirred tanks
A *axial-conveying propeller mixer*
B *radial-conveying plate mixer*
C *flow impeder*

BASIC KNOWLEDGE

AGGLOMERATION

Agglomeration is the opposite of comminution. The terms agglomeration, granulation and pelletisation designate the process of particle size enlargement of solids. Powderous fine material is joined together to form larger particle bodies. The particle bodies can be designated as flock, granulate, agglomerate, pellets, briquettes or tablets. The reason for employing an agglomeration process may be to improve the flow behaviour, to enhance mixability, to reduce dust creation, or to alter shape, size, porosity, strength, etc.

A rough distinction can be made between the following agglomeration methods:

- **Constructive agglomeration**
  Individual, free-moving particles are agglomerated together to form larger bodies, or are agglomerated onto existing particle bodies. Often liquids are used as the binding agent. Constructive agglomeration may occur in fluidised beds.
  In rolling agglomeration, large particle bodies are formed by snowballing. The technical application is implemented by way of dish or drum granulators or mixers.

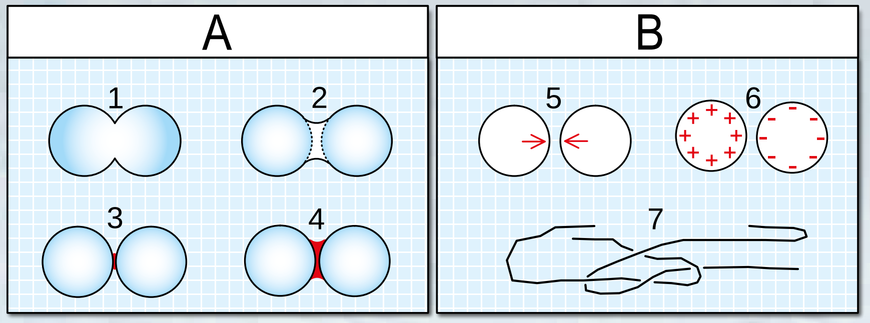
- **Compression agglomeration**
  An agglomeration is formed from a powderous solid by the action of external compression forces. In tablet production, the powder is compressed in a die with a stamp. Another application is roller pressing, using two smooth rollers (resulting in uneven agglomerations) or rollers with trough-like recesses (resulting in mouldings such as briquettes).

- Other processes: **flocculation** to separate suspensions from liquids; **sintering**.

Different binding mechanisms, with differing adhesive forces, take effect depending on the process (see illustration). A fundamental distinction can be made between mechanisms which involve material binding and those which do not. The most stable are solid archs created by sintering. Solid archs may also be created by other processes if thermo-setting or crystallising binding agents are used.

In constructive agglomeration, adhesion by liquid archs is of primary importance. Depending on the ratio of liquid to solid, the type of liquid and the pore shape and size, adsorption layers permanently bonded to the surface or free-moving liquid archs are produced.

In the case of van der Waals' forces and electrostatic forces, there is no material binding. Van der Waals' forces play a major role in compression agglomeration. Positive bonds occur in fibrous materials such as paper and felt.



Binding mechanisms in agglomerates:
A *mechanisms involving material binding*
B *mechanisms without material binding*
1 *solid arch by sintering*
2 *solid arch made of thermo-setting or crystallising binding agent*
3 *solid arch with permanently bonded adsorption layer*
4 *free-moving liquid arch*
5 *attraction by van der Waals' forces*
6 *electrostatic attraction*
7 *positive bond*

CE 320 Stirring

*** Visualisation of flow fields when using various stirrer types**

*** High-performance stirring machine with speed control**

*** Determination of mixing time of solutions**

*** Mixing of emulsions and suspensions**

*** Influence of mixing processes on heat transfer**

*** Power demand during stirring**

Technical Description

During stirring, the continuous phase is liquid. With CE 320, the production of solutions (solid dissolved in liquid), emulsions (mixture of immiscible liquids) and suspensions (insoluble solid in liquid) can be investigated.

Mixing takes place in a tank which is resistant to chemicals and heat-resistant. With the high-performance stirring machine even high-viscosity mixtures can be produced. The speed is adjustable. The torque is indicated on the unit's digital display. This enables the power demand to be determined.

Nine different, easily interchangeable stirrers are provided. With plastic balls which are dispersed in the water it is possible to observe the characteristic flow fields of the different stirrer types. Flow impeders can be inserted in the tank to investigate their influence on the mixing process. To determine the mixing time and mix quality of solutions, a conductivity meter is available. The device can also be used to measure temperatures.

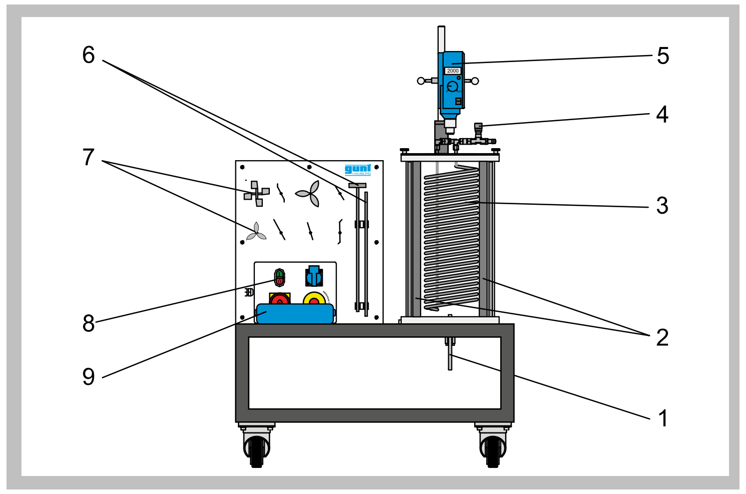
A removable coiled tube serves as a heat transfer medium. It can be used for heating or cooling with water from the laboratory supply. A valve with precise adjustment is used to adjust the flow rate. This enables the influence of mixing processes on heat transfer to be investigated.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

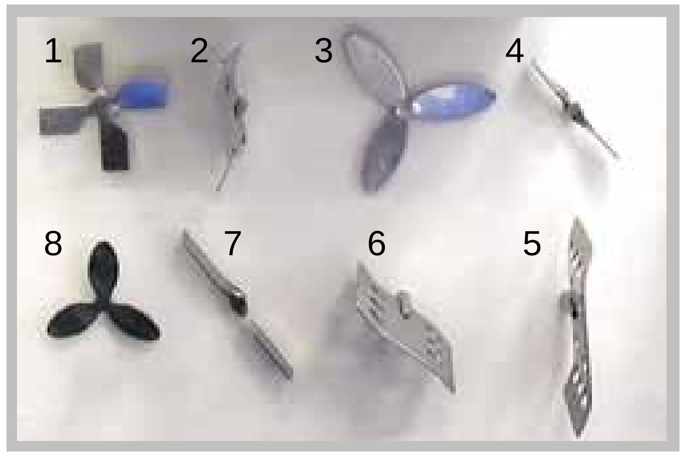
Learning Objectives / Experiments

- flow fields of various stirrer types
- power demand, mixing time, mix quality dependent on
  - * stirrer type
  - * speed
  - * materials used (density, viscosity)
  - * insertion of flow impeders
- observation of the suspension state of suspended solids when using different stirrers and at different speeds
- observation of the droplet size of emulsions when using different stirrers and at different speeds
- influence of mixing processes on heat transfer

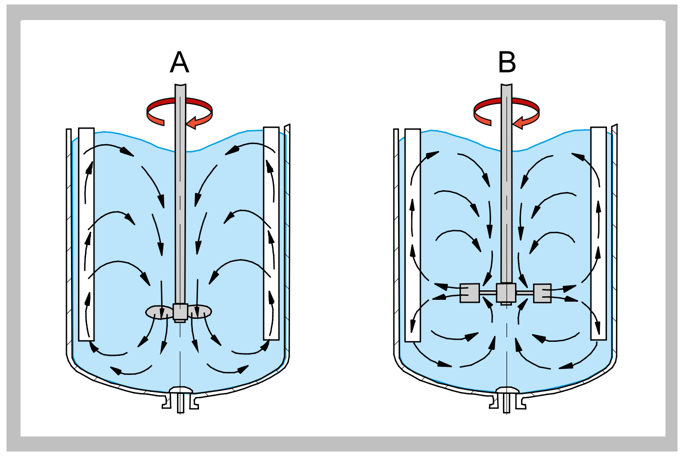
CE 320 Stirring



1 outlet valve, 2 flow impeder, 3 coiled tube, 4 coiled tube valve, 5 stirring machine with speed and torque indicator, 6 turbine stirrer and threaded shaft for stirring heads, 7 stirring heads (8 in total), 8 switch box, 9 conductivity meter with probe in case



Stirring heads: 1,3,8 propeller stirring heads, 2,5,6 paddle stirring heads, 4,7 propeller stirring heads, angled



Flow fields in the stirred tank with axial-conveying stirrer (A) and radial-conveying stirrer (B)

Specification

[1] investigation of mixing processes during stirring
[2] transparent stirred tank with 4 removable flow impeders
[3] speed-controlled stirring machine with digital torque indicator
[4] 9 interchangeable stirrers:
axial-, radial-, tangential-conveying
[5] removable coiled tube for cooling or heating with external water supply
[6] portable device for measuring conductivity and temperature

Technical Data

Stirred tank
- capacity: approx. 20L
- material: DURAN glass and PVDF (base)

Stirring machine
- speed: 50...2000min^{-1}
- max. power output on shaft: 100W

Stirrers
- 5 propeller stirring heads
  - 2x 3 blades, D=70mm / 100mm
  - 1x 4 blades, D=70mm
  - 2x 2 blades (angled), D=70mm / 100mm
- 3 paddle stirring heads
  - 2x paddle: 70x70mm with 3 / 6 holes
  - 1x paddle: 70x100mm with 10 holes
- 1 turbine stirrer with shaft: D=50mm

Coiled tube
- diameter: approx. 140mm
- material: stainless steel

Measuring ranges
- conductivity: 0...200mS/cm
- temperature: 0...85°C
- speed: 50...2000min^{-1}

Dimensions and Weight

LxWxH: 850x600x1950mm
Weight: approx. 83kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase
Water connection for coiled tube: 200...300L/h

Scope of Delivery

1 experimental unit
8 different stirring heads
1 threaded shaft
1 turbine stirrer
1 conductivity meter in case
1 packing unit of plastic balls
1 Allen key
1 set of instructional material

Order Details

083.32000 CE 320 Stirring

CE 255 Rolling Agglomeration

*** Rolling agglomeration with a dish granulator**

*** Strength testing of agglomerates to assess the process**

*** Practical experiments on a laboratory scale**

Technical Description

The terms agglomeration, granulation and pelletisation designate the process of particle size enlargement of solids. This trainer was developed in cooperation with the **Department of Mechanical Engineering and Process Engineering at the Niederrhein University of Applied Sciences in Krefeld**.

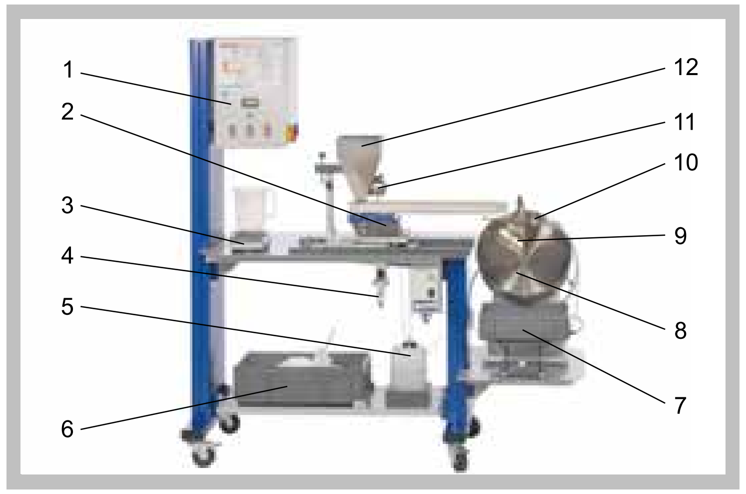
A powder (fine material) is continuously fed onto an inclined, rotating dish granulator. A pump delivers granulating liquid to a two-component nozzle. The liquid is atomised over the powder by compressed air. Starting from a small number of moistened particles, a rolling motion produces growing numbers of balls (agglomerates). The fine material in the moved layer tends to remain close to the bottom. It is lifted higher than the forming agglomerates by the rotary motion of the dish. The ball-shaped agglomerates roll along the surface of the layer. When they have attained a certain size, they drop off the rim of the disc. The agglomerates are collected in a tank. Two further tanks are provided for the solid material (for which powdered limestone is recommended) and the granulating liquid (sugar powder diluted in water). The mass flow of solid feed material, the flow rate of the liquid, the speed and the angle of inclination of the disc are adjustable. The compressive strength of the resultant agglomerates can be measured using a laboratory device. To determine these and other key properties of the agglomerates, a balance and drying chamber are also recommended.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

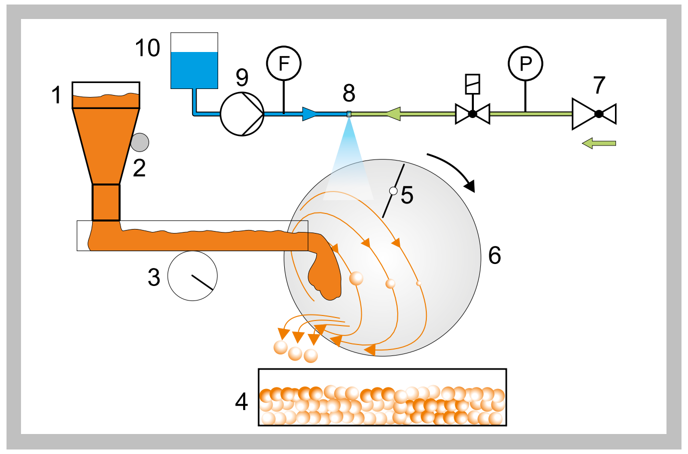
Learning Objectives / Experiments

- learning the basic principle and method of operation of an agglomeration unit
- agglomerate size and strength dependent on
  * mass flow of solid feed material
  * flow rate of liquid
  * ratio of solid to liquid
  * dish rotation speed
  * angle of inclination of dish
  * position of solid and liquid feed
  * selected solid
  * selected granulating liquid

CE 255 Rolling Agglomeration



1 switch cabinet, 2 solid material metering device, 3 balance, 4 pressure reducing valve, 5 granulating liquid tank, 6 solids tank, 7 agglomerate tank, 8 dish granulator, 9 scraper, 10 two-component nozzle, 11 vibrator, 12 solids silo



1 solids silo, 2 vibrator, 3 solid material metering device, 4 agglomerate tank, 5 scraper, 6 dish granulator, 7 pressure reducing valve, 8 two-component nozzle, 9 pump, 10 granulating liquid tank; F flow rate, P pressure

Agglomerates

Specification

[1] rolling agglomeration with a dish granulator
[2] dish granulator with adjustable rotation speed and angle of inclination
[3] metering device to adjust the mass flow of solid feed material
[4] two-component nozzle to atomise the granulating liquid with compressed air
[5] peristaltic pump to adjust the flow rate of liquid
[6] air pressure adjustment by pressure reducing valve
[7] positions of solid and liquid feed adjustable
[8] tanks for solid, granulating liquid and agglomerates

Technical Data

Dish granulator
- diameter: approx. 400mm
- rim height: approx. 100mm
- material: stainless steel

Dish drive motor
- power consumption: approx. 750W
- speed: 20...400min^{-1}

Pump
- max. flow rate: approx. 428mL/min

Tanks
- solids silo: approx. 10L
- granulating liquid: 5L
- agglomerates: 10L
- solids: 40L

Measuring ranges
- flow rate: 0...100mL/min
- pressure: 0...10bar
- speed: 4...70min^{-1}

Dimensions and Weight

LxWxH: approx. 1810x810x1800mm
Weight: approx. 200kg

Required for Operation

230V, 50Hz, 1 phase
Compressed air connection: 1...6bar

Scope of Delivery

1 trainer
1 balance
1 shovel
1 measuring cup
1 packing unit of powdered limestone
1 set of instructional material

Order Details

083.25500 CE 255 Rolling Agglomeration

BASIC KNOWLEDGE

STORAGE AND FLOW OF BULK SOLIDS

The term “bulk solids” generally refers to materials in the form of collections of single or individual particles. These particles may be very fine (powder) or coarse. Examples are ores, cement, foodstuffs or chemical products. Bulk solids are stored in tanks, containers or silos, depending on quantity. The storage facilities must be designed such that they neither impair product quality nor cause disturbances to the removal of the bulk solids.

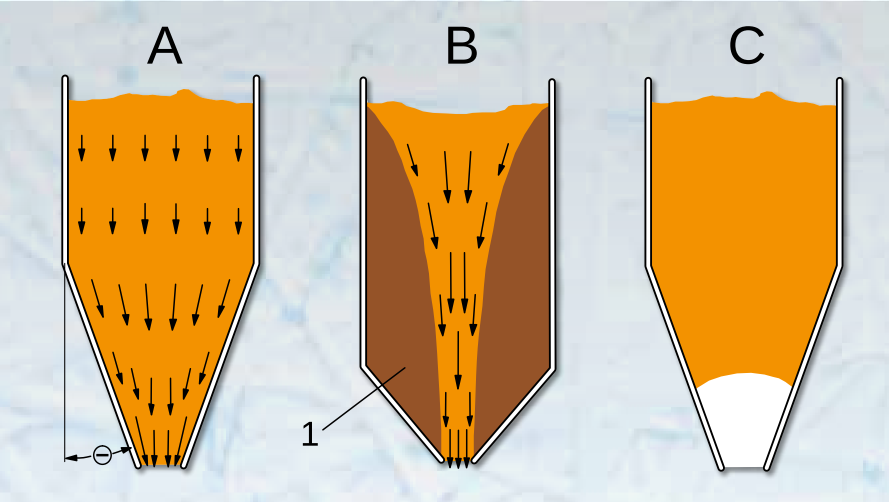
Bulk solids do not behave like Newtonian fluids either when flowing or when at rest in storage. In contrast to Newtonian fluids, bulk solids can also transmit transverse strain when at rest, and accordingly form surfaces which tend to be stable. Nor are analogies with the behaviour of solids usually possible. For example, in contrast to solids, a bulk solid cannot transmit any significant tensile stresses.

Consequently, in order to describe the behaviour of bulk solids there is a dedicated discipline known as bulk mechanics or powder mechanics, which is founded on that of soil mechanics.

For more information on the subject: Schulze, D.: Powders and Bulk Solids, Springer, Berlin Heidelberg New York (2007)

Typical phenomena when bulk solid is flowing out of a hopper or silo are:

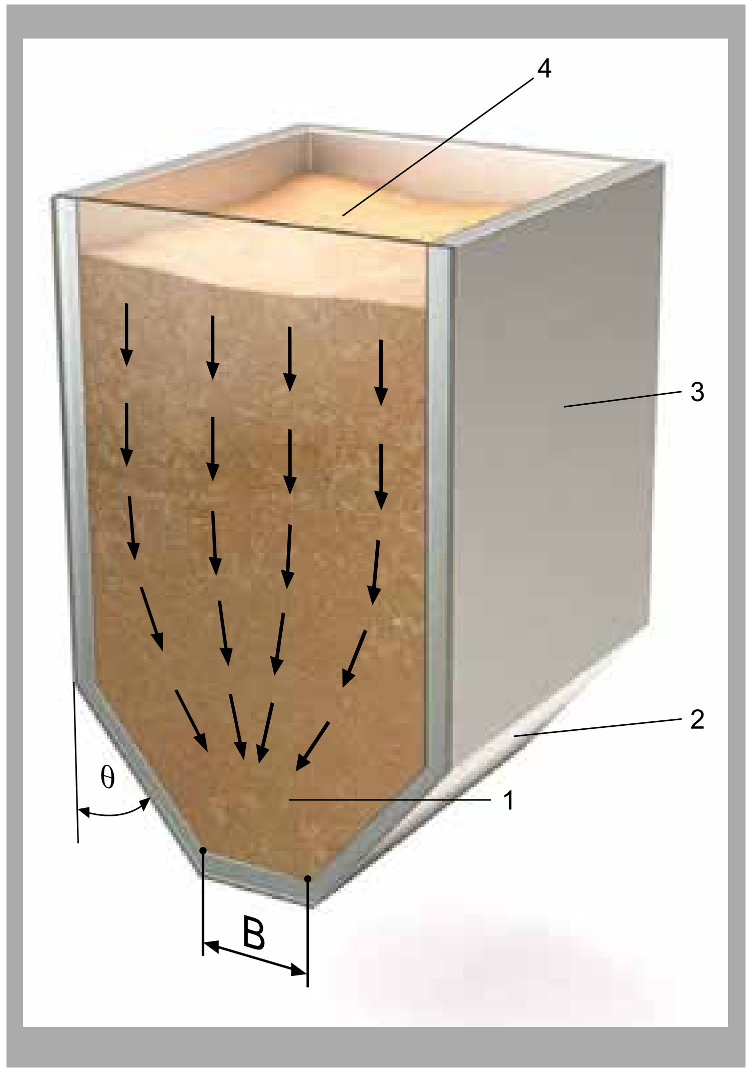
- **Mass flow**
  The entire vessel contents are in motion during discharge of the bulk solid. If the area above the hopper is high enough, a uniform sinkage across the cross-section occurs (piston flow).
- **Funnel flow**
  Only a limited zone above the discharge opening, which can widen out upwards in a funnel shape, is in motion during discharge of the bulk solid. At the sides of the flowing bulk so-called dead zones are formed, in which the material is at rest. The material rests in those zones for a long time, and is only discharged towards the end of the emptying process. Moreover, a bulk solid which is not very free-flowing may become compacted in the dead zones to such an extent that it will not flow out by gravity alone.
- **Arching**
  In the case of poor flowing, cohesive bulk solids, a stable arch may form in the discharge hopper causing the material flow to come to a stop.
- **Segregation**
  When filling storage containers, segregation may occur if the particles are of differing size, shape or density. Segregation by its nature reduces product quality.



A *mass flow,* ***B*** *funnel flow,* ***C*** *arching*
Θ angle of hopper wall, ***1*** *dead zones*

Whether mass or funnel flow is occurring depends on the flow properties of the bulk solid and on the wall material and angle of inclination of the hopper walls. The required angle of the hopper walls can be calculated if the flow properties are known. The flow properties are measured using shear testers. With these measured values, the minimum size of the discharge opening to avoid arching can also be calculated.

CE 210 Flow of Bulk Solids from Silos



1 transparent front wall, 2 hopper wall, 3 side wall, 4 bulk solid;
Θ angle of hopper wall, B width of outlet cross-section

* Observation of flow profiles

Technical Description

This trainer was developed in cooperation with **Prof. Dr. Schulze (from Braunschweig / Wolfenbüttel University of Applied Sciences)**. It permits observation of flow profiles as bulk solids flow out of silos. To that end, two identically shaped silos with transparent front walls and differing hopper wall materials are provided. As well as the influence of the wall material, the influence of the hopper wall angle of inclination on the outflow behaviour can also be investigated. It is possible to verify segregation processes during filling and emptying by means of sampling at the outlet and analysis using a sieve.

Learning Objectives / Experiments

- influence of wall material and angle of inclination of hopper wall on flow profile (mass/funnel flow) and outflow time
- segregation processes
- arching

Specification

[1] investigation of the outflow of bulk solids from silos with wedge-shaped discharge hoppers
[2] 2 silos with differing hopper wall materials
[3] angle of inclination of hopper wall stepwise variable while outlet cross-section remains constant
[4] front walls of silos made of transparent material
[5] 2 coloured bulk solids with differing particle size ranges to visualise the flow profiles
[6] sieve to examine the segregation
[7] stopwatch to determine times taken to flow out
[8] demonstration of arching by moistening of the bulk solid
[9] practical verification of the design results obtained with CE 200 with regard to mass flow/funnel flow

Technical Data

2 silos with wedge-shaped hoppers
- base body cross-section: approx. 200x200mm
- width of outlet cross-section: approx. 30mm
- height: approx. 600mm
2 bulk solids
- particle size ranges:
  approx. 100...250 / 250...500µm
Sieve mesh width: approx. 250µm

Dimensions and Weight

LxWxH: 800x600x1100mm
Weight: approx. 80kg

Scope of Delivery

1 trainer (2 silos)
1 sieve
1 balance
1 stopwatch
2 packing units of bulk solid (plastic granulate)
1 set of instructional material

Order Details

083.21000 CE 210 Flow of Bulk Solids from Silos

CE 200 Flow Properties of Bulk Solids

* **Determination of the flow properties of bulk solids using a ring shear tester for the design of silos**
* **Easy handling based on unlimited shear travel**
* **Professional analysis software**

Technical Description

The flow properties of a powder or bulk solid determine how it behaves during handling. For example, material may flow irregularly out of silos, or the flow of bulk solid may come to a stop. In order to avoid these problems in practice, silos can be designed on the basis of measurements using shear testers, such as the Jenike shear tester or a ring shear tester.

In a ring shear tester, a bulk sample is contained in a ring-shaped shear cell. A normal force is exerted on the sample by way of a lid. A hanger from which a variable weight is suspended generates this normal force. A motor moves the shear cell relative to the lid in order to apply shear to the sample. For compaction (pre-shearing) the sample is subjected to a large normal force. An electronically amplified force transducer measures the shear forces which are then recorded by data acquisition software over time. After pre-shearing, shearing to failure is executed with a reduced normal force (strength measurement) and likewise recorded by the software. From the shear force characteristics, properties such as the compressive strength and internal friction of the bulk solid can be determined. To determine the density of the bulk solid, the volume of the bulk sample is ascertained by recording the lowering of the lid using a vernier caliper gauge. So as to also take into account the influence of the hopper wall material on the outflow behaviour, a separate measurement is performed with a ring-shaped sample of the wall material.

An evaluation software is available to determine the flow properties from the experimental results. The flow properties identified are used to determine the optimum geometry of a silo's discharge hopper. Trainer CE 210 is provided for practical verification of the design results obtained in terms of mass flow/funnel flow. The ring shear tester and the evaluation software were developed by **Prof. Dr. Schulze (from Braunschweig / Wolfenbüttel University of Applied Sciences)**.

Learning Objectives / Experiments

- recording the shear force characteristics of bulk solids
- yield locus and wall yield locus design
- determination of flow properties
  * compressive strength
  * internal friction
  * density
  * wall friction angle
- determination of the optimum hopper geometry of a bulk solids silo

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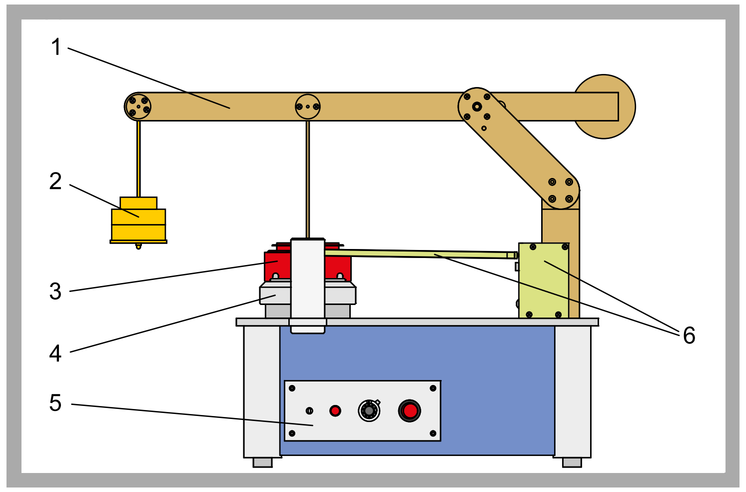
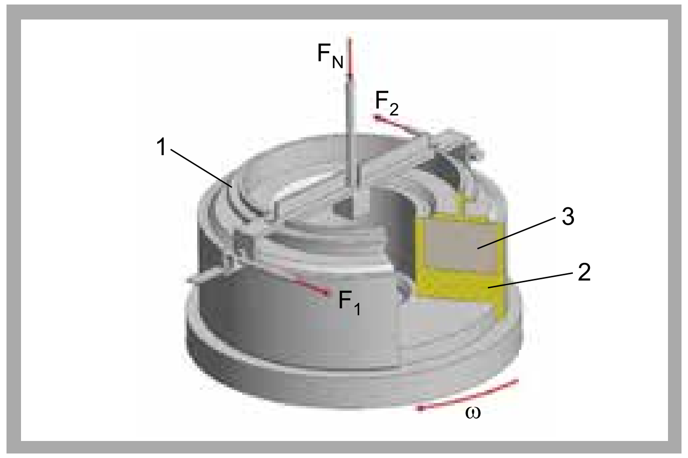
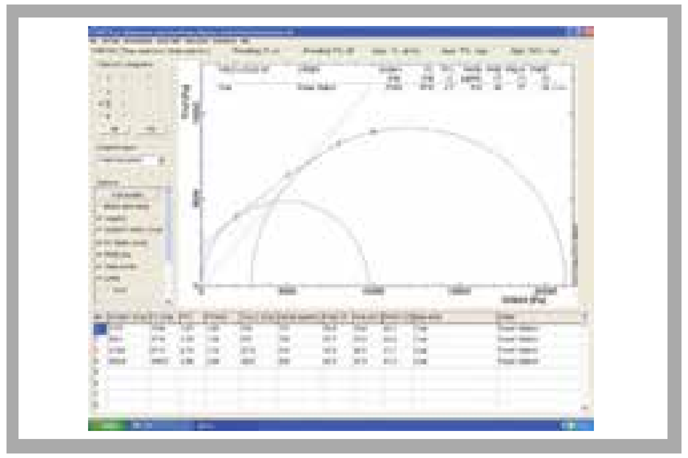
CE 200 Flow Properties of Bulk Solids



1 loading system for generation of normal force, 2 weights, 3 shear cell, 4 drive unit, 5 controls, 6 force sensor (shear force) with tie rod



Shear cell for determination of yield loci: 1 lid, 2 shear cell, 3 bulk solid; F_1, F_2 shear forces, F_N normal force, ω direction of rotation of shear cell



Screenshot from evaluation software: yield locus with Mohr's circles

Specification

[1] design of bulk solids silos using a ring shear tester
[2] 1 ring-shaped shear cell to determine yield loci
[3] 1 ring-shaped shear cell with sample of wall material to determine wall yield loci
[4] shearing of the bulk solid sample by motor rotation of the shear cell
[5] vertical loading of the sample via ring-shaped lid with weights
[6] force sensor to measure the shear forces
[7] vernier caliper gauge to measure the change in height and density of the bulk sample
[8] GUNT software to record the shear force characteristics via USB under Windows Vista or Windows 7
[9] evaluation software to determine the relevant bulk solid parameters

Technical Data

Shear cell
- sample volume: approx. 70cm^3
- material: aluminium

Shear cell with sample of wall material
- sample volume: approx. 15cm^3
- material: aluminium

Motor
- power consumption: max. 75W
- speed: 500...3000min^{-1}

1 set of weights
- 4x 500g
- 2x 200g
- 2x 100g
- 2x 50g

Measuring ranges
- shear force: 0...40N
- balance: 0...1000g

Dimensions and Weight

LxWxH: approx. 400x240x330mm
Weight: approx. 18kg

Required for Operation

230V, 50/60Hz, 1 phase and 120V, 60Hz, 1 phase

Scope of Delivery

1 experimental unit
1 shear cell
1 shear cell with sample of wall material
1 vernier caliper gauge
1 GUNT software cd + USB-cable
1 evaluation software
1 packing unit of bulk solid
1 balance
1 set of instructional material

Order Details

083.20000 CE 200 Flow Properties of Bulk Solids

BASIC KNOWLEDGE

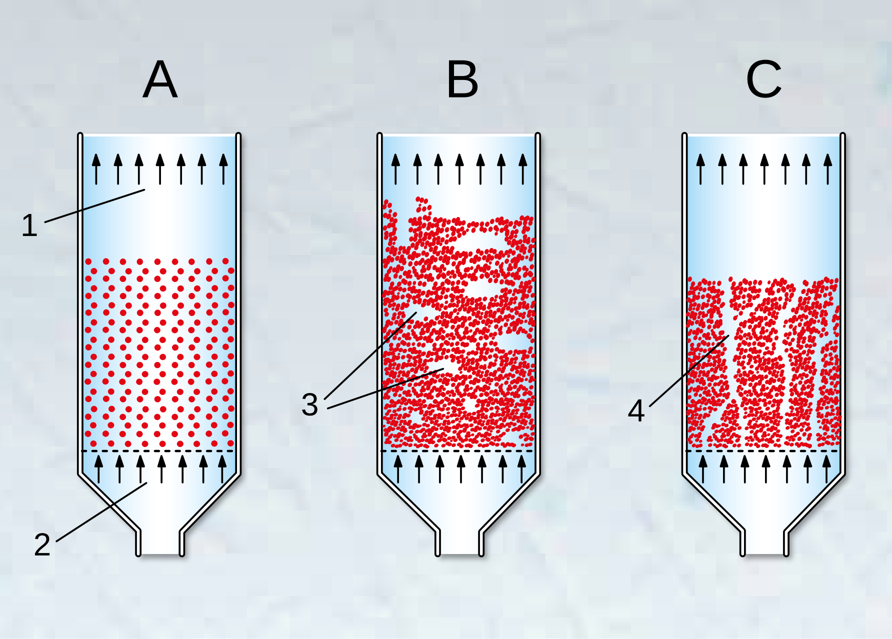
FLUIDISED BEDS

A fluidised bed involves two phases: a solid and a fluid (gas or liquid). If a fluid flows through a resting layer of bulk solid at an adequate velocity (fluidisation velocity), the layer is loosened so that individual solid particles enter a suspended state. This state is termed fluidisation. The fluidised bed created in this way behaves similarly to a liquid in terms of flow and thermodynamics.

If the velocity is excessive, particles are discharged from the fluidised bed. Hydraulic or pneumatic transport begins.

Owing to the large contact surfaces between the solid and fluid, heat and material transport processes between the particles and the fluid, and among the particles themselves, are encouraged.

One application of this is in fluidised bed combustion, where combustion takes place in a fluidised bed made of comminuted fuel and hot combustion air. The fluidised bed principle permits low combustion temperatures. As a result, very low nitrogen oxide emission limits can be achieved.



Fluidised bed forms:
A homogeneous fluidised bed
B bubbling fluidised bed
C channeling
1 fluid outlet, 2 fluid inlet, 3 bubbles, 4 channel

The following forms of fluidised bed may occur:

- **Homogeneous fluidised bed**
  As the flow velocity of the fluid increases, a uniform volumetric dilation of the fluidised bed occurs. The solid particles are evenly distributed across the entire layer. In reality, behaviour of this kind is to be observed only in liquids when using particles of equal size.

- **Inhomogeneous fluidised bed**
  Classification or sorting processes take place in the fluidised bed. Specifically heavier particles are enriched in the lower zone. When using gases as the fluid, bubbling almost always occurs in the fluidised bed. The bubbles are free of solids. Smaller bubbles merge on their way to the surface to form larger bubbles. At the surface they burst. The surface of the fluidised bed looks like a boiling liquid.

- **Channeling**
  If a fine-grained bulk solid is used as the solid, and if the individual particles adhere to each other, formation of a fluidised bed may not occur. Instead, flow channels are created. There is no flow through the surrounding zones. With such solids, a fluidised bed can only be created by additional stirring.

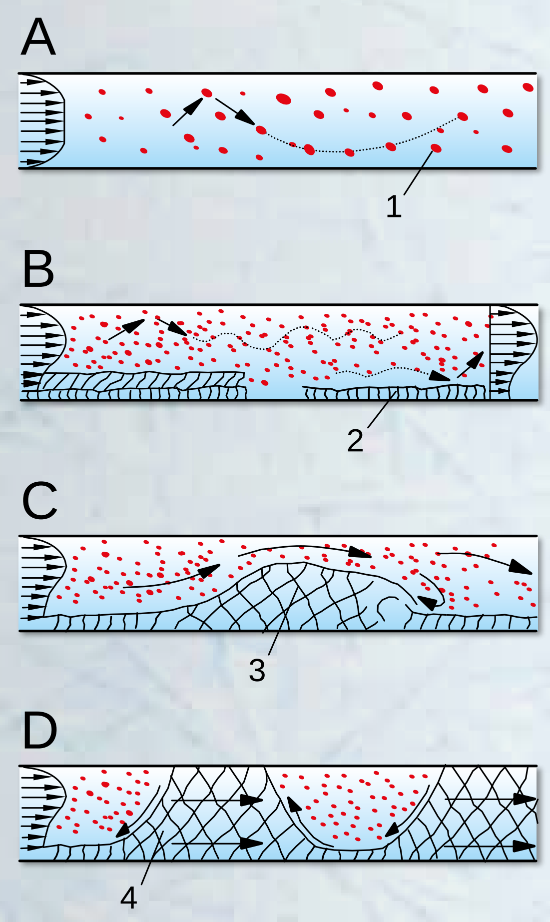
BASIC KNOWLEDGE

PNEUMATIC TRANSPORT

Pneumatic conveyor systems transport powderous and granular bulk solids by means of a gas flow (mostly air) in pipelines. The bulk solids may be foodstuffs such as grain or pulses for example.

Pneumatic conveyor systems essentially consist of an air compressor, a conveying line and a dust separator (e. g. gas cyclone). Transport may be effected horizontally, vertically, or occasionally inclined.

Typically the conveyor line may be connected to the intake (suction or vacuum) or delivery (positive pressure) side of the air compressor. Combination suction / positive pressure systems also exist. Vacuum conveying systems have a beneficial feature in that the vacuum in the system does not permit any dusty air to leak out. Positive pressure conveying systems enable transport over greater distances and differences in height than vacuum conveyors.



Transport states with velocity profiles in horizontal pipelines:
A suspension flow or dilute phase transport
B intermediate flow or strand transport
C dense phase dune transport
D dense phase plug transport
1 solid particles, 2 strands
3 plug or slug formation from a dune
4 moving plug

Depending on the velocity and solid content of the airflow, different transport states may occur in *horizontal* pipelines:

- **Suspension flow or dilute phase transport**
  At high velocities the solid particles move through the line distributed uniformly across the cross-section. Particles impact against each other or against the pipe wall.
- **Intermediate flow or strand transport**
  If the velocity is reduced while the solid content remains constant, the energy of the flow is no longer sufficient to hold the entire solid mass suspended. Some of the solid particles slide along the bottom of the pipe in the form of strands. The rest are transported in suspension above the strands.
- **Dense phase dune transport**
  If the velocity is reduced further, the solid particles move like a dune. Particles are moved over the summit of the dune and are deposited on its sheltered side. If the velocity is reduced further, incipient plugs may be formed from the dunes which occupy a major part of the cross-section of the pipe.
- **Dense phase plug transport**
  At very low velocities the material occupies the entire cross-section of the pipe and plugs are formed. Plugs advance slowly. If the air compressor does not have sufficient pressure reserves, plug transport may quickly lead to blockage of the pipeline.

In *vertical* pipes the same transport states occur in principle, though gravity is more of an influencing factor.

Not all materials are capable of being transported in dense phase. The detailed behaviour observed in the conveying line is highly dependent upon the particular material's characteristics.

CE 220 Fluidised Bed Formation

*** Experimental investigation of the fluidisation process**

*** Comparison of fluidised bed formation in gases and liquids**

*** Pressure loss in fixed beds and fluidised beds**

*** Optimum observation of processes through transparent tanks**

Technical Description

Bulk solids can be transformed from a fixed bed into a fluidised bed when liquids or gases pass through them. The areas of application of fluidised beds include the drying of solids and a wide variety of chemical processes.

CE 220 features two transparent test tanks for fluidised bed formation in water and air. A diaphragm pump delivers water from a storage tank into the bottom of the left side test tank. The water flows upwards through a porous sintered-metal plate. On the sintered-metal plate is a bulk solid. If the velocity of the water is less than the so-called fluidisation velocity, the flow merely passes through the fixed bed. At higher velocities the bed is loosened to such an extent that individual solid particles are suspended by the fluid. If the velocity is increased further, particles are carried out of the fluidised bed. A filter at the top of the test tank holds these particles back. The water flows back into the storage tank.

The right-side test tank is similar in construction to the left-side one. An air flow generated by a compressor flows through it.

Manometers are mounted on both test tanks to measure the pressure loss. The flow rates are adjusted by way of valves, and can be read from flow meters. The test tanks are removable. This makes it easy to change the bulk solid filling.

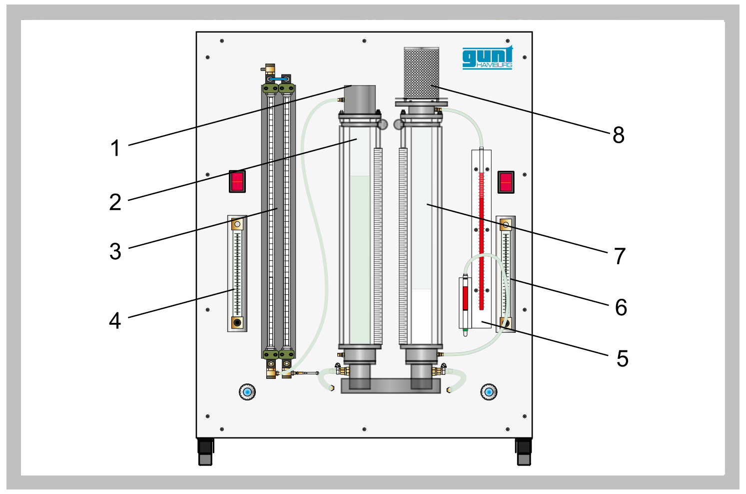
Glass-shot beads in a range of particle sizes are provided as the bulk solid filling.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

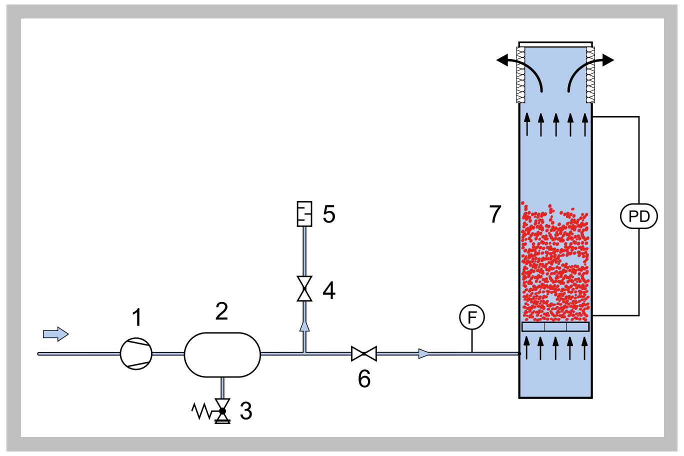
Learning Objectives / Experiments

- fundamentals of the fluidisation of bulk solids
- observation and comparison of the fluidisation process in water and air
- pressure loss dependent on flow velocity
- pressure loss dependent on the type and particle size of the bulk solid
- determination of the fluidisation velocity and comparison with theoretically calculated values (Ergun equation)
- dependency of the height of the fluidised bed on the flow velocity
- verification of Carman-Kozeny equation

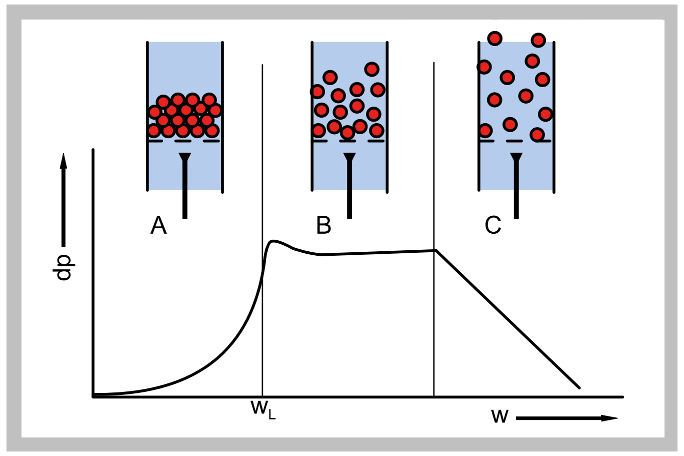
CE 220 Fluidised Bed Formation



1 water overflow, 2 test tank for water, 3 twin tube manometers, 4 flow meter for water, 5 U-tube manometer, 6 flow meter for air, 7 test tank for air, 8 filter



Compressed air supply: 1 compressor, 2 compressed air accumulator, 3 safety valve, 4 bypass valve, 5 sound absorber, 6 needle valve, 7 test tank (air); F flow rate, PD differential pressure



Pressure loss characteristic on a homogeneous fluidising bed: dp pressure loss, w flow velocity, w_L fluidisation velocity;
A fixed bed, B fluidised bed, C transport

Specification

[1] investigation of fluidised bed formation of solids in air and water
[2] 2 transparent test tanks to observe fluidised bed formation in air/water
[3] 1 manometer per tank to measure the pressure loss through each test tank
[4] 1 steel rule per tank to measure the change in height of the fluidised beds
[5] both test tanks removable for filling
[6] storage tank with diaphragm pump for water supply
[7] diaphragm compressor with compressed air accumulator for compressed air supply
[8] adjustment of flow rate for both media by valves and flow meter

Technical Data

2 test tanks
- length: 550mm
- inside diameter: 44mm
- scale division: 1mm
- Material: PMMA

Diaphragm pump (water)
- max. flow rate: 1,7L/min
- max. head: 70m

Diaphragm compressor (air)
- max. flow rate: 39L/min
- max. pressure: 2bar

Tanks
- water storage tank: approx. 4L
- compressed air accumulator: 2L

Measuring ranges
- pressure (water): 0...500mmWC
- pressure (air): 0...200mmWC
- flow rate (water): 0,2...2,2L/min
- flow rate (air): 4...32L/min

Dimensions and Weight

LxWxH: 750x610x1010mm
Weight: approx. 80kg

Required for Operation

230V, 50/60Hz, 1 phase or 120V, 60Hz/CSA, 1 phase

Scope of Delivery

1 experimental unit
1kg glass-shot beads (180...300µm)
1kg glass-shot beads (420...590µm)
1 set of instructional material

Order Details

083.22000 CE 220 Fluidised Bed Formation

CE 250 *Pneumatic Transport*

*** Pneumatic pressure-lifting of solids in a vertical tube**

*** Transparent tubes and tanks to observe different transport states**

*** Practical experiments on a laboratory scale**

Technical Description

Pneumatic conveyors can be used to transport dispersed solids over great distances in pipelines.

The solid is transported out of a feed tank via a vibrating trough into an air flow. An interchangeable injector disperses the solid in the air flow. The air flow transports the solid upwards in the tube. The transport terminates in a collector tank.

Depending on the velocity and solid content of the air flow, different transport states may occur. At high velocities, the solid is dispersed evenly across the cross-section of the tube (dilute phase transport). If the velocity is reduced, strands and balls form on the wall of the tube which then slide down owing to their higher settling velocity. The strands and balls disintegrate again in the air flow and reform. Reducing the velocity to below the settling velocity of the individual particles ultimately results in plug transport. The different transport states can be observed through the transparent tube.

To identify the pressure loss and the flow velocity, measuring points are provided at all relevant positions. The velocity of the air flow is adjusted by a pressure regulator. The solid mass flow can be adjusted by way of the throw of the vibrating trough on a potentiometer. The compressed air has to be provided from the laboratory supply.

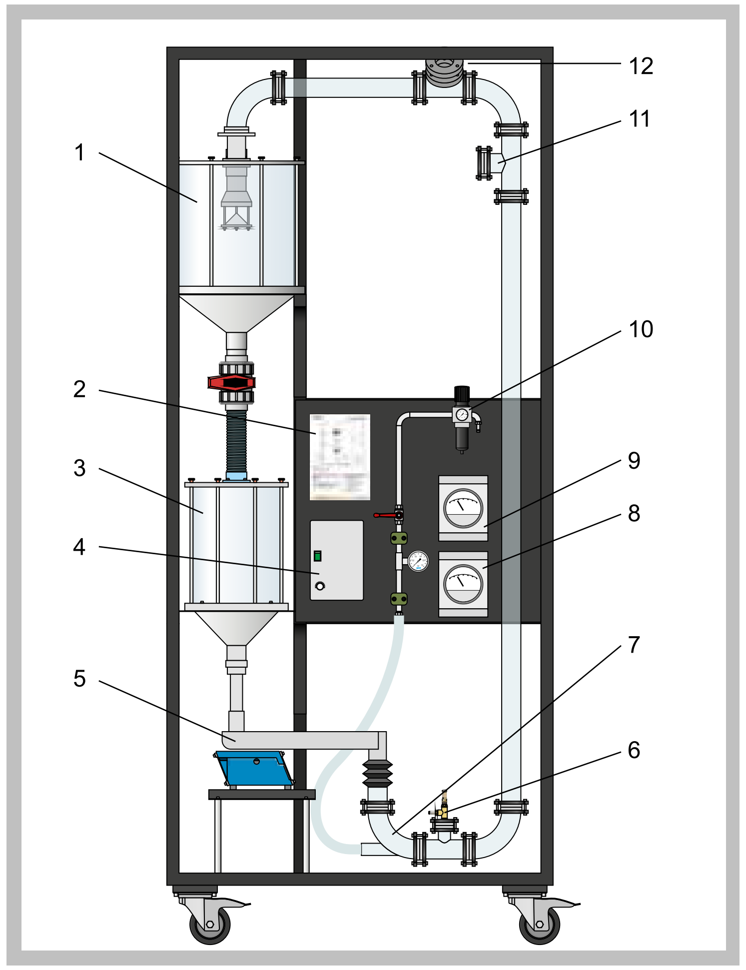
Peas or plastic granulate are recommended for use as the solid.

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

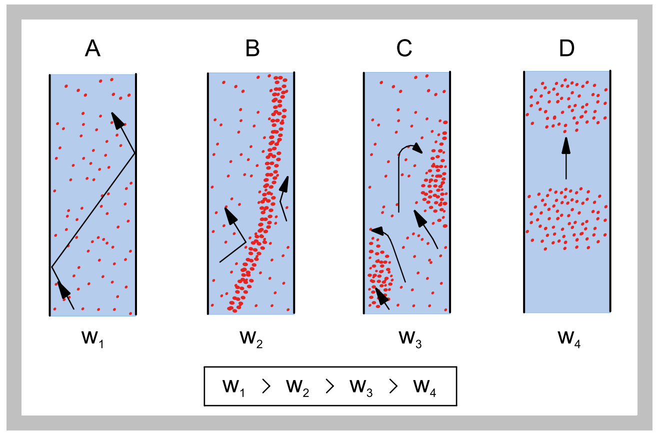
Learning Objectives / Experiments

- learning the fundamental principle and method of operation of a pneumatic conveyor system
- observation of different transport states dependent on solid content and air velocity
- determination of the suspension velocity of the solid
- determination of the solid content of the flow
- pressure loss dependent on solid content and air velocity

CE 250 *Pneumatic Transport*



1 collector tank, 2 process schematic, 3 feed tank, 4 vibrating trough controls, 5 vibrating trough, 6 pressure measurement point, 7 injector, 8 differential pressure indicator, 9 velocity indicator, 10 precision pressure regulator, 11 velocity measurement point (Pitot tube), 12 pressure measurement point



Transport states in vertical transport: A dilute phase transport, B strand transport, C ball transport, D plug transport;
w air velocity

Specification

[1] pneumatic pressure-lifting of solids in a vertical tube
[2] feed of solid into air flow via vibrating trough with adjustable throw
[3] 4 interchangeable injectors to disperse the feed material into the air flow
[4] vertical tube made of glass
[5] collector and feed tanks made of transparent material (PMMA)
[6] collector and feed tanks interconnected by tube with plug valve
[7] precision pressure regulator to adjust input pressure and flow rate
[8] measuring points for pressure loss, temperature and flow velocity

Technical Data

Vertical tube
- height: 2m
- diameter: 50mm

Tanks
- feed: 20L
- collector: 40L

Measuring ranges
- velocity (vertical tube): 0...36m/s
- differential pressure (vertical tube): 0...10kPa
- pressure (inlet): 0...1bar
- temperature: 0...60°C

Dimensions and Weight

LxWxH: approx. 1280x800x2880mm
Weight: approx. 190kg

Required for Operation

230V, 50Hz, 1 phase
Compressed air connection: min. 1500mbar and 60m^3/h

Scope of Delivery

1 trainer
4 injectors
1 set of instructional material

Order Details

083.25000 CE 250 Pneumatic Transport