Wiegand® Plants for Processing Fermentation Products

Production of bio-based substances
of the chemical industry and food industry

engineering for a better world

GEA Process Engineering

GEA Wiegand – Custom-made Designs

Technical competence

GEA Wiegand is one of the prominent manufacturers of plants for thermal and mechanical process engineering with core competencies in evaporation, distillation, membrane filtration, jet pumps and vacuum systems and offers a broad range of plants and technologies for the processing of fermentation solutions and waste water.

Research and development

GEA Wiegand has its own research and development center with numerous laboratories and pilot plants. Test data are evaluated here and the product-specific parameters are determined for each individual plant design.

Pilot plants are available for

- Evaporation
- Membrane filtration
- Distillation
- Fermentation
- Mixing
- Gas scrubbing

Most plants are mobile and can be used both in the laboratory and for tests at customer's facilities. Process combinations with other technologies are tested, such as separators and decanters by GEA Westfalia Separator, driers by GEA Niro and GEA Barr Rosin or crystallization plants by GEA Messo.

In detail this implies

- Performance of laboratory tests, including analytical evaluation with GC and HPLC for organic acids, alcohol, sugar
- Advancement and further development of existing plants
- Development/optimization of processes, e. g. by combination of several processes
- Determination of physical substance data for the design of equipment, piping and pumps

Range of delivery and services

We offer consultation, engineering, calculation, design, manufacture, delivery, quality control, commissioning and after sales service, plant extension and energy optimization.

Innovations

GEA Wiegand today relies on the experience gained in more than 100 years of continuous research and development, project engineering and construction. This means one century of successful market and above all customer-oriented product development according to the latest technological standards.

International orientation

In Germany and abroad the plants of GEA Wiegand can be found in many industrial sectors. We sell our products through a well-organized network of GEA Wiegand sales offices. GEA Wiegand is represented in many countries of the world by its own companies and agencies.

Plants for Processing Fermentation Products

Process flow sheet

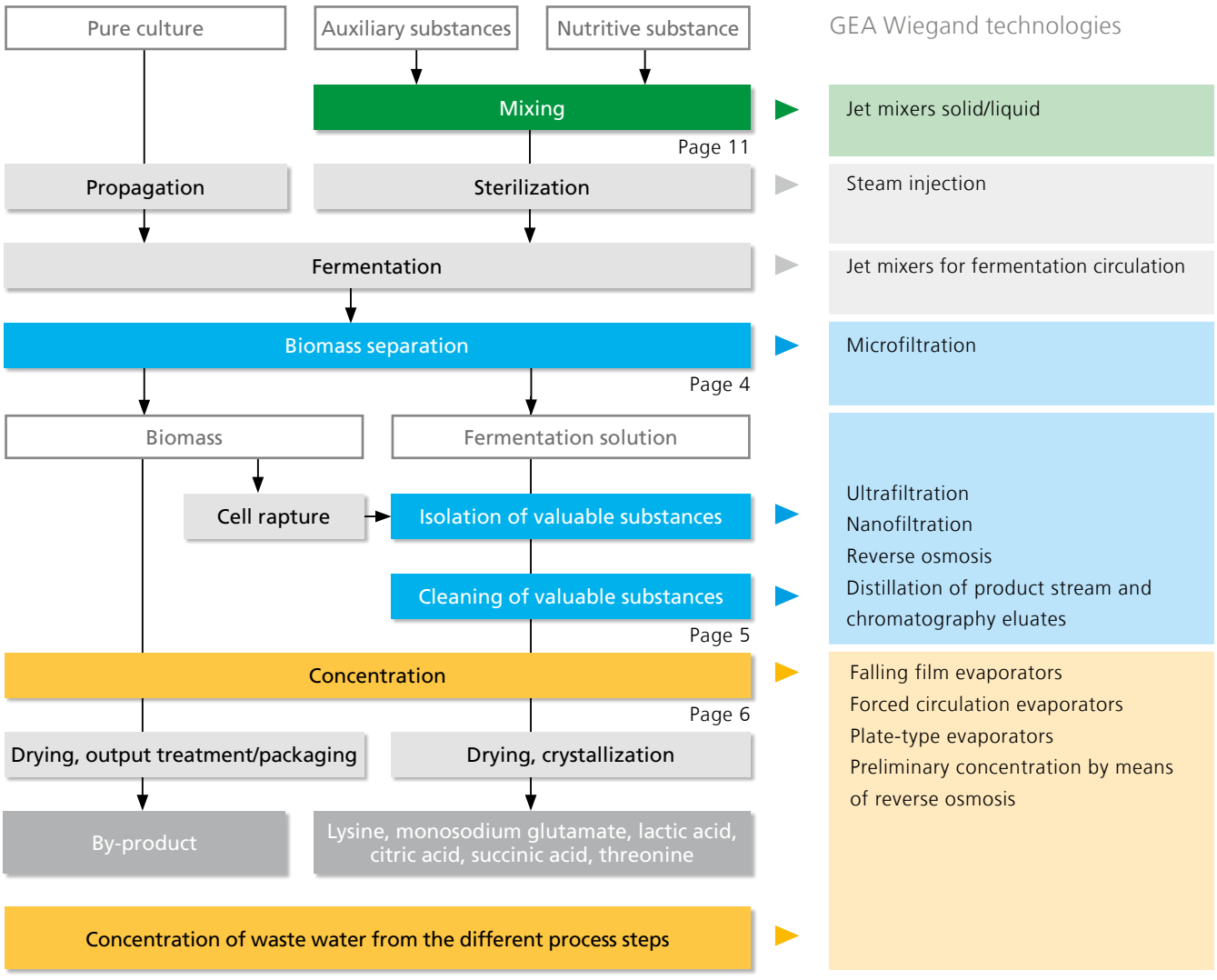
The flow sheet shows the basic sequence of a fermentation process with possible adjacent technologies.
GEA Wiegand's range of products is colour-coded. The following pages provide you with detailed descriptions of the technological systems, illustrated by examples of implemented plants.

Starting situation

Many primary products of chemical and food industry are produced from renewable resources by fermentation:

Bio-chemicals	Food and feed additives
■ Succinic acid	■ Yeast and yeast extract
■ Lactic acid	■ Monosodium glutamate
■ Propandiol	■ Citric acid
■ Butandiol	■ Lysine
	■ Threonine

Numerous process steps are necessary for the further processing of these substances to the respective final product.



Biomass Separation, Isolation of Valuable Substances

Biomass separation

The biomass separation by means of membrane filtration has the crucial advantage that a solid-free fermentation solution (filtrate) can be produced in a continuous and almost maintenance-free operation.
Genetically modified or pathogenic organisms are contained in this process. Preferably, ceramic membranes are used. Alternatively, combinations of centrifuges and membrane plants with spiral wound modules are used.

Features

- Solid-free filtrate/permeate, thus the use of inexpensive spiral wound elements is possible during the subsequent isolation of valuable substances
- Large selection of different membrane types
- CIP/SIP (Cleaning in place / Sanitization in place) is possible at high temperatures and in large pH ranges

Isolation of valuable substances

After the biomass has been separated, the valuable substances are isolated from the fermentation solution. For this purpose, ultrafiltration and nanofiltration are the preferred membrane processes. When the fermentation solution is free from solids, economical spiral wound modules can be used. For products of which membrane processes are not able to achieve a sufficient isolation of the valuable substances, chromatography processes will be applied.

Membrane processes

In microfiltration, ultrafiltration, nanofiltration and in reverse osmosis the product tangentially flows over the membranes (cross flow) contrary to the normal cake filtration (dead end). This allows a continuous operation over extended periods of time.
GEA Wiegand relies on the well-proven GEA Filtration technology and uses all usual membrane types (ceramic and polymeric tube modules, hollow fibre modules and spiral wound modules).

Features

- Extremely energy-efficient processes
- Low thermal load
- Compact, modular plant design
- 24 hours operation can be realized due to redundant design (arrangement in parallel and sequential cleaning)
- Sanitary construction, CIP/SIP possible
- Completely automated operation with GEWI Flex control system
- GEA Filtration expert's assessment regarding the process and membrane selection

Top: Microfiltration plant with ceramic membranes for biomass separation

Bottom: Ultrafiltration plant for the isolation of valuable substances (spiral wound elements)

Purification of Valuable Substances, Preliminary Concentration

Purification of valuable substances

Undesirable substances are removed from the isolated valuable substances in a fine purification step. Ultrafiltration and nanofiltration are particularly suitable for the efficient purification of product since impurities can be specifically separated. The yield can be increased applying a diafiltration in which additional water can be injected into the concentrated solution.
If no adequate purification can be achieved with membrane filtration, chromatography processes can be applied.

Left: Ceramic modules

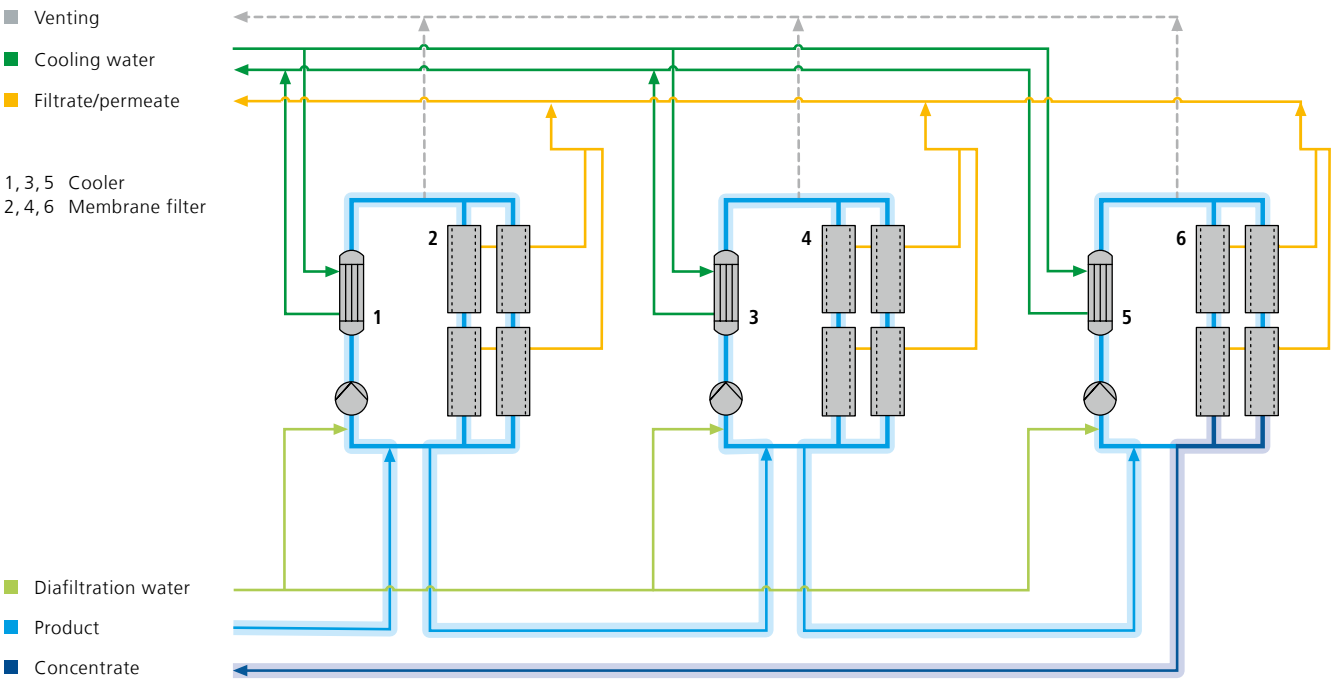
Bottom: Flow sheet of an ultrafiltration plant with ceramic membranes

Preliminary concentration

In comparison to thermal processes, membrane processes show considerable advantages regarding the operating costs. They are therefore often used as preliminary phases for evaporation plants, especially for aqueous solutions and in the case of low viscosities.

Features

- Energy-efficient concentration process
- Optional degree of preliminary concentration, depending on the product properties
- Optimal plant combinations by GEA Wiegand experts' assessment in membrane and evaporation technology
- Tested plant designs for the minimization of product losses
- Use of the permeates in upstream-arranged process steps possible



Concentration of Fermentation Products

Single-effect falling film evaporation plant with mechanical vapour recompression
Evaporation rate: 40 t/h

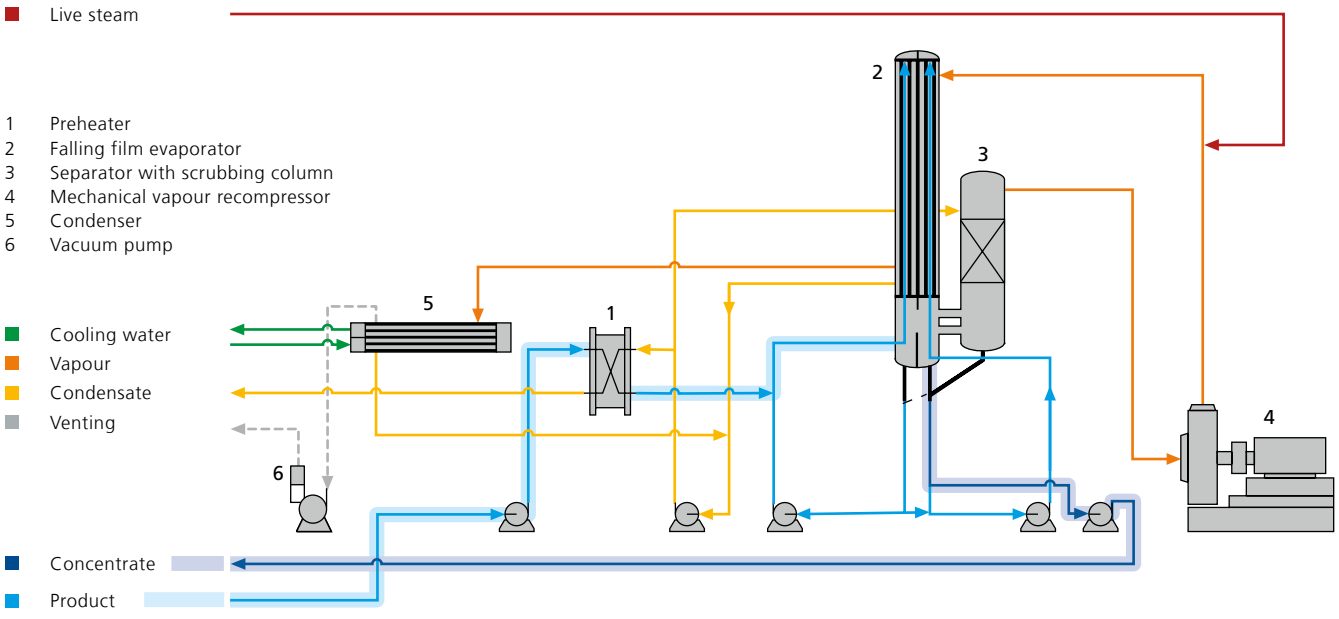
After the biomass separation and further treatment steps, the fermentation solutions are concentrated in falling film evaporators up to a solid content of 50 % DS. The further concentration and crystallization then takes place in forced circulation evaporators and in crystallizers.

Energy-efficient design

Usually, evaporation plants are designed as multi-effect plants and are heated either directly or by means of thermal vapour recompression. In case of high steam costs the heating of the plants using mechanical vapour recompression offers an interesting and economical alternative.

Plant characteristics

- Single-effect falling film evaporator with internal product pipes, thus improved product preheating and reduced insulation and installation expenditures
- Energy-efficiency due to mechanical vapour recompression
- Scrubbing column for separation and/or recovery of volatile, water-soluble product components
- Evaporation rates of 3 to 70 t/h



High final concentrations

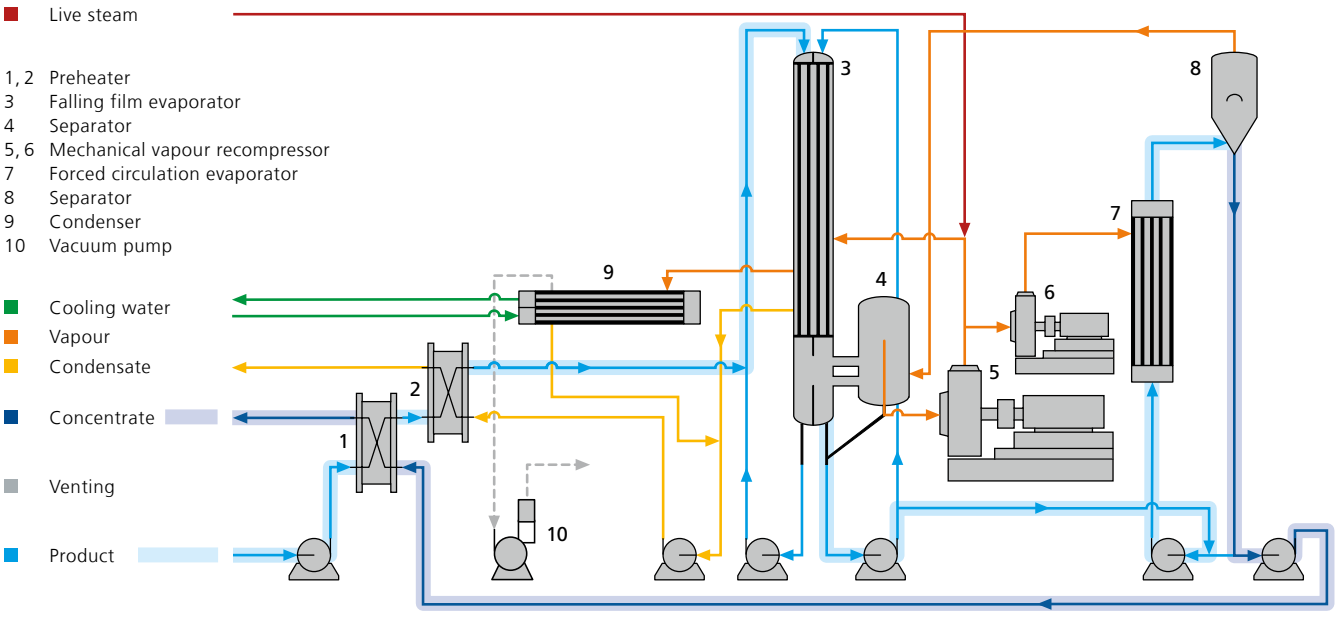
Depending on the required concentration and plant capacity, up to three mechanical vapour recompressors (fans) are arranged in series. In case of high final concentrations, an additional steam-heated finisher is used - even with thermal vapour recompression.

Plant characteristics

- Single-effect falling film evaporator with mechanical vapour recompression
- High final concentrations, with a forced circulation evaporator as finisher, heated via an additional mechanical vapour recompressor
- Evaporation rates of 5 to 70 t/h

The design of these plants is complex, because of a super-proportional boiling point elevation with increasing concentration. This negatively affects the function of the vapour recompressor. For the calculation of such evaporation plants we rely on profound experience with these products for many years.

Evaporation plant with 2 fans for mechanical vapour compression and a forced circulation evaporator as finisher
Evaporation rate: 67 t/h



Concentration of Fermentation Products

Special requirements

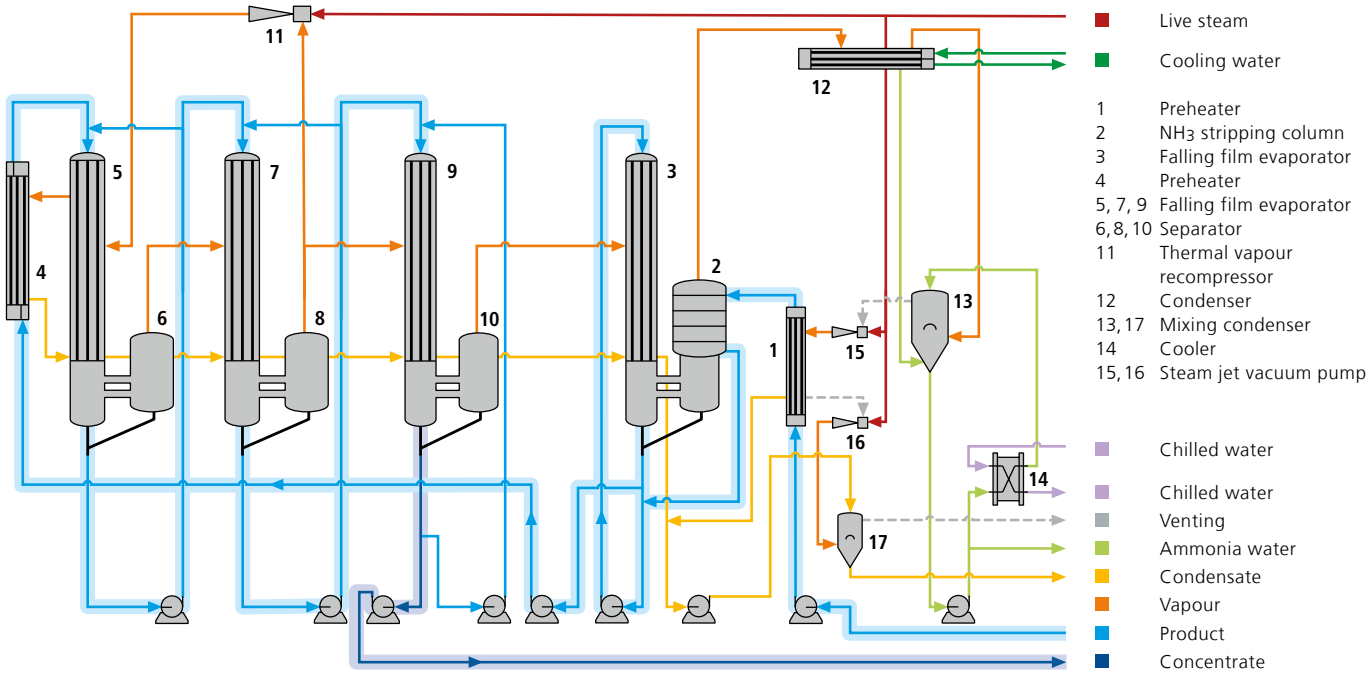
When producing a product such as lysine, the fermentation solutions contain considerable portions of ammonia which essentially evaporate together with the vapour thus contaminating the condensate. In the plant example a stripping column is arranged upstream of the evaporators in order to separate and concentrate the majority of ammonia. The vapour condensates then only contain small quantities of ammonia and in this way can be re-used in the process.

Other products, such as e. g. lactic acid or propandiol are volatile to a certain extent and on the basis of their equilibrium conditions they are converted into vapour during evaporation. In order to avoid product losses and impurities of the condensates, scrubbing columns are installed on the separators of the evaporation effects. These scrubbing columns will almost completely retain the product with only a minor increased energy expenditure, compare sketch on page 6.

4-effect falling film evaporator with thermal vapour recompression for lysine solution with stripping column for NH_3 separation and condensation
Evaporation rate: 47 t/h

Plant characteristics

- Energy-efficient tanks to multi-effect design with thermal vapour recompression
- Upstream arranged NH_3 stripping column for ammonia separation
- Vacuum generation by steam jet vacuum pumps
- Evaporation rates of 10 to 50 t/h



Concentration of Fermentation Waste Water

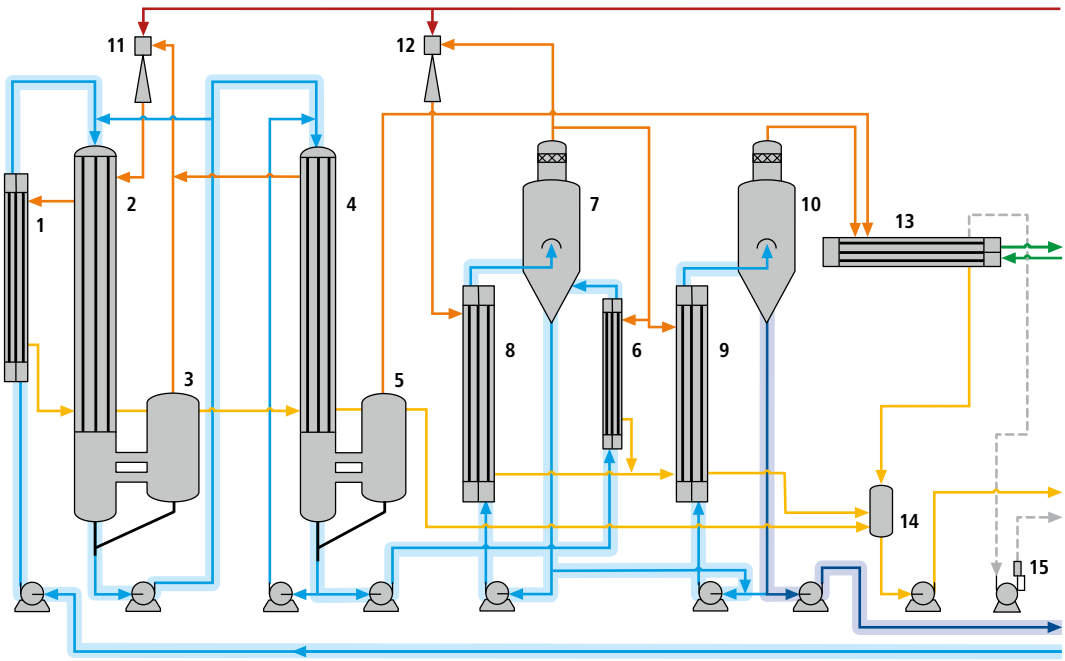
Optimal design

Waste water occurring in the production of fermentation products is often strongly organically loaded and very saline. Therefore, the suitable evaporator type has to be selected, unless contamination of the heat transfer surfaces has to be expected during the concentration. Moreover, fermentation waste water is corrosive to a large extent and therefore care has to be taken when selecting the materials. An economical solution can be achieved when selecting a combination of metallic materials (e. g. titanium) – for the heat transferring parts – and plastic materials (e. g. glass-fibre reinforced plastic). The optimally designed evaporation plants of GEA Wiegand stand out for long service lives allowing economical operation with simultaneously long life of the plants.

Plant characteristics

- 2-effect falling film evaporator and 2-effect forced circulation evaporator, each with thermal vapour recompression
- Made of corrosion-resistant materials
- Evaporation rates of 10 to 100 t/h

4-effect falling film/forced circulation evaporation plant with thermal vapour recompression for fermentation waste water Evaporation rate: 31 t/h



- Live steam
- 1 Preheater
- 2, 4 Falling film evaporator
- 3, 5 Separator
- 6 Preheater
- 7, 8 Forced circulation evaporator
- 9, 10 Forced circulation evaporator
- Cooling water
- 11, 12 Thermal vapour recompressor
- 13 Condenser
- 14 Condensate level tank
- 15 Vacuum pump
- Vapour
- Condensate
- Venting
- Concentrate
- Product

Solvent Recovery

Fermentation processes for the production of cell cultures, cell components or cellular products are often connected with the use or the formation of organic solvents (e. g. alcohols or esters) which due to different volatility can be separated from mixtures or liquids by means of distillation in fermentation or downstream processes.
Solvents occur in the extraction, precipitation or ion exchange/ chromatography. For processes such as e. g. isopropanol recovery in the production of xanthan gum or carrageenan gum, GEA Wiegand delivers custom-made plants with distillation technology and distillation hybrid processes.

Features

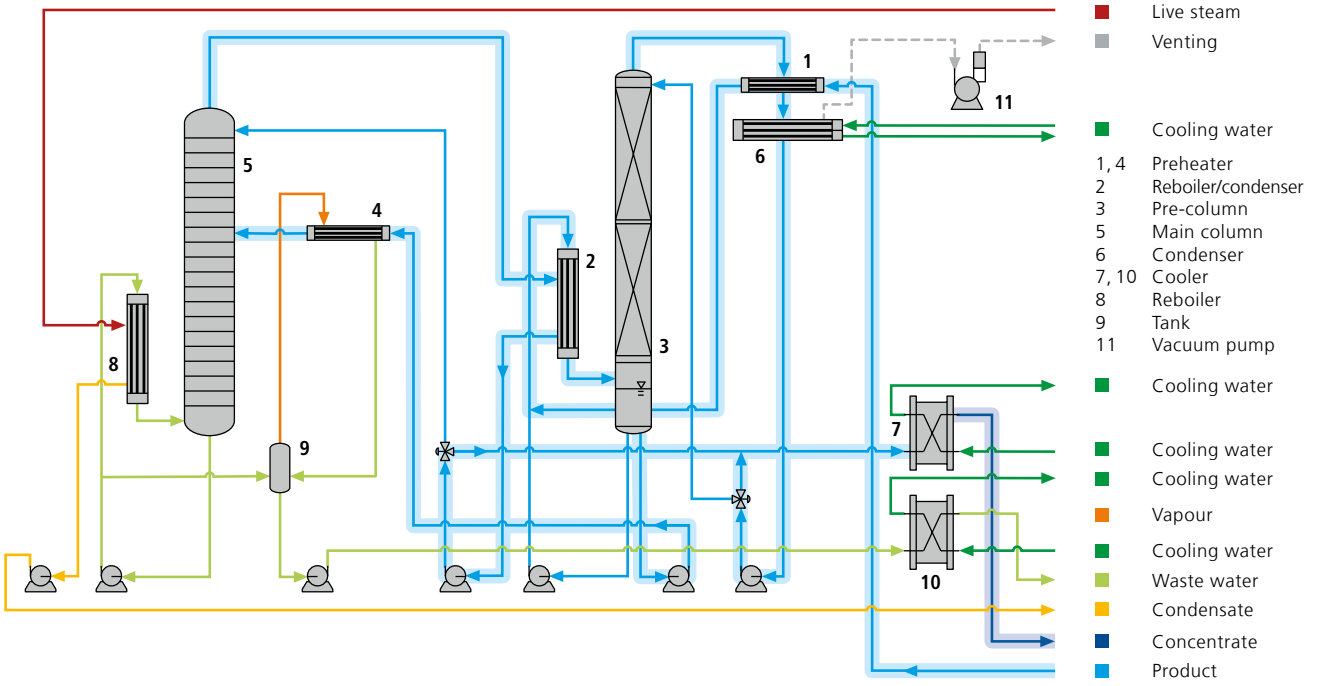
- Optimal solvent recovery
- Highest energy efficiency with cascade or compressor system with mechanical vapour recompression
- Continuous operating mode for solvent quantities of approx. 0.5 - 50 t/h
- Batch systems with intelligent process control for solvent quantities smaller than 0.5 t/h

For the design of these trayed or packed column systems GEA Wiegand relies on efficient simulation tools and on specific design software, on substance data bases or distillation tests in the laboratory. Local tests at our customers' facilities are also possible with GEA Wiegand's mobile pilot plants.

Energetically optimized IPA distilling plant for typical capacities with feed rates of 20 to 100 t/h

Specific detailed engineering

GEA Wiegand is not only experienced in actual distillation technology, but also has the know-how in the field of the traditional fermentation technology (process lines for yeast and alcohol production) and therefore is able to design specifically detailed engineering for individual fermentation steps according to the customers' specifications, e. g. substrate sterilization, batch, Fed batch or Konti fermenter effects.



Mixing, Pumping, Heating

Circulating and mixing

Liquid jet mixers are used to circulate and mix fluids in fermentation tanks. If one or several mixers are optimally arranged there is a three-dimensional flow which homogeneously mixes the tank contents.
Thereby the yield is increased and the fermentation time is reduced.

Pumping and conveying

Liquid jet solids pumps convey granular product by means of a motive fluid. The product to be conveyed generally is fed to the jet pump via a funnel and is entrained by the motive jet.
The high speeds in the jet pump provide for a good mixing of the solid matters with the liquid. The formation of lumps is avoided.
During the mashing process, a fine suspension is produced.

Heating

Steam jet preheaters are used to heat fluids in tanks or pipes. The mash is heated to liquefaction temperature by direct steam injection.

Overview on our range of products

Evaporation plants
to concentrate any type of fluid food, organic and inorganic process solutions and industrial waste water.

Membrane filtration – GEA Filtration
to concentrate and process fluid food and process water, to improve quality and to recover valuable substances.

Distillation and rectification plants
to separate multi-component mixtures, to recover, clean and dehydrate bio-alcohol of different qualities.

Alcohol production lines
to produce potable alcohol and dehydrated alcohol of absolute purity; with integrated stillage processing systems.

Condensation plants
with surface or mixing condensers, to condense vapour and steam/gas mixtures, mainly under vacuum.

Vacuum/steam jet cooling systems
to produce cold water, to cool liquids and product solutions, even of aggressive and abrasive nature.

Jet pumps
to convey and mix gases, fluids and granular solids, for direct heating of fluids as heat pumps.

Steam jet vacuum pumps
also with product steam as motive medium and in combination with mechanical vacuum pumps (hybrid systems).

Heat recovery systems
to utilize residual heat from exhaust gases, steam/air mixtures, waste steam, condensate and product.

Vacuum degassing plants
to remove dissolved gases from water and other liquids.

Heating and cooling systems
mobile and stationary systems; for the operation of hot-water-heated reactors and contact driers.

Jet gas scrubbing systems
to purify and de-dust exhaust air, separate aerosols, cool and condition gases, condense vapour, absorb gaseous pollutants.

Project studies, energy optimization, engineering
for our plants and systems.

Excellence Passion Integrity Responsibility GEA-versity

GEA Group is a global mechanical engineering company with multi-billion euro sales and operations in more than 50 countries. Founded in 1881, the company is one of the largest providers of innovative equipment and process technology. GEA Group is listed in the STOXX Europe 600 Index.

GEA Process Engineering

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