

Thermal Treatment of Industrial Waste Water



Content

Technologies, Research and Development	3	Waste Water from the Production of Wood Fibre Boards (MDF)	8
Oil-Water Emulsions	4	Waste Water from Wood Steaming	9
Waste Water Containing Oil and Salts, from Waste Disposal Companies and Tank and Barrel Cleaning	5	Waste Water from Biotechnology	10
Waste Water from Industrial Laundries	6	Organic Waste Water from the Food and Starch Industry	12
Toxic Waste Water from Chemical Production Processes	7	Waste Water from Olive Oil Production	14
		Fermentation Residuals from the Bio-gas Production	15



Thermal Treatment of Industrial Waste Water

There are many industrial uses for water: process water, rinsing water, scrubbing and cooling water are typical industrial applications.

This implies that there are large quantities of industrial waste water with strong contaminations of different composition. In most of the cases, this waste water has to be treated in in-house systems before it can be discharged into the public sewage system or to rivers, lakes or to the sea.

An economical and environmental friendly waste water treatment should be an integral part of the overall planning of a factory or plant.

HERE, THE MAIN QUESTIONS ARE:

- Where does the waste water accumulate?
- Is it possible to reduce the waste water quantities?
- Which treatment allows the recycling of the water or its contents?
- What are cost-efficient and environmentally compatible options of disposal?

GEA Wiegand supports you to find solutions to these tasks. As one of the world's leading manufacturers of thermal-mechanical process engineering with core competence in evaporation, distillation and membrane filtration we offer tailor-made plants for the special requirements, including additional upstream or downstream process steps. Thanks to the combination of suitable processes our plants achieve optimum results for the water quality and for the recovery of valuable substances.

Technologies

Thermal separation of substances is particularly suited if the waste water cannot be clearly defined, and if its ingredients, dry substance contents, pH value or particle size changes frequently and if it should be highly concentrated.

When designing evaporation and distillation plants, numerous requirements must be taken into consideration, for example product-specific substance values, energy conditions and the overall local situation.

The selection of the type of construction and arrangement is based on these parameters, as are the other process engineering and operational data.

Energy consumption essentially determines operating costs of evaporation and distillation plants. With our ingenious thermo-technical arrangement, you can reduce the energy requirement of a complete plant to a minimum.

ENERGY SAVING POTENTIALS ARE:

- Heating with waste heat
- Multi-effect evaporation
- Thermal vapour recompression
- Mechanical vapour recompression

GEA Wiegand checks the customer's energy situation before designing a plant in order to offer the best economical solution. If special particle sizes and substances have to be removed, membrane filtration plants are combined with evaporation plants for a selective separation of the impurities. Membrane filtration plants are either used as an initial effect to recover specific valuable substances, to pre-concentrate upstream of an evaporation plant, or to treat vapour condensate coming from a thermal treatment system. Depending on the application, smaller waste water quantities are treated in membrane filtration systems only.

For an optimal separation, several membrane filtration processes can be applied: reverse osmosis, nanofiltration, ultrafiltration and microfiltration.

Research and development

GEA Wiegand maintains a research and development centre with numerous laboratory plants; in these plants, important data are determined for the selection and design of the appropriate plants. Some pilot plants are mobile and with these mobile plants we can carry out tests at our customers' facilities.

Up to the present, more than 4,500 tests have been run in our testing facilities. The alphabetic list of test products ranges from A like acetone/alcohol mixture to Z like zinc dichloride.



MAIN FEATURES OF GEA WIEGAND WASTE WATER TREATMENT SYSTEMS:

- Tailor-made plant designs
- Combination of several process steps
- Max. concentration of the waste water
- Min. use of chemical substances
- Complete separation of solid matters
- Absolutely salt-free water (distillate)
- Low residual quantities, low disposal costs
- Recycling of condensate as process water
- Good partial-load behaviour
- High operational reliability
- Long service life

GEA Wiegand engineered plants are renowned for their high quality and economic efficiency. We strictly observe all criteria of the process requirements and we place special emphasis on a reliable and operator-friendly operation of our plants.

Our scope of services includes consultancy, engineering, calculation, design, manufacture, delivery, quality control, commissioning and after-sales service.

THE NAME GEA WIEGAND STANDS FOR:

- Experience of 100 years of Wiegand technology and more than 4,000 plants delivered all over the world
- Extensive product knowledge
- Numerous patents in Germany and abroad
- Own research and development centre with pilot plants in laboratory scale
- World-wide sales network
- Certification according to DIN EN ISO 9001
- Member of the international GEA Group

Oil-Water Emulsions

In the metal-working industry, oil-water emulsions are used as a cooling agent and as a lubricant. After an expensive regeneration they are re-used several times, but after a certain period they have to be renewed.

It is the objective of the treatment to separate the oily substances from the watery portions. The contamination of the water should be as low as possible prior to it being discharged to a sewage treatment plant, or prior to being re-used in the factory; the oily content should be highly concentrated and transferred, for example, to an incineration plant. Thermal separation in an evaporation plant is a process which can fulfil this task.

Process description

The coarse solid matters and the free oils are separated, the waste water is filtered once again and conveyed to the evaporation plant. The waste water is concentrated to approx. 30 % in a falling film pre-evaporator. This part of the plant is heated by mechanical vapour recompression, which is an energy-saving process. High concentration takes place in a forced circulation evaporator.

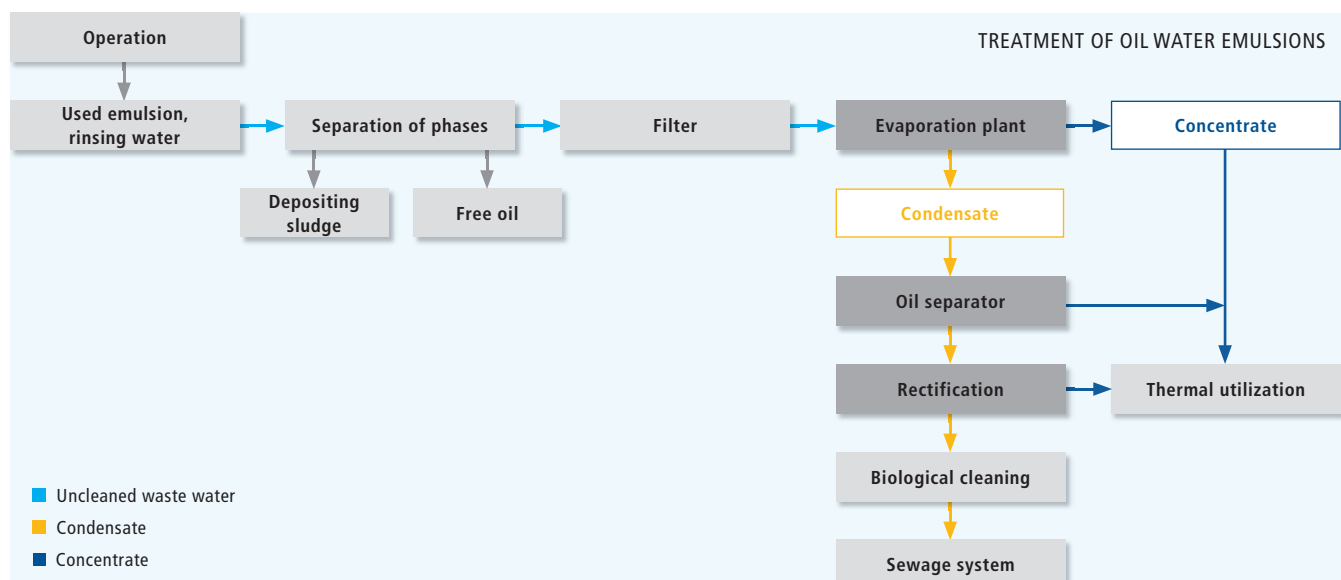
In most of the cases, the vapour condensate still contains oil and has to be transferred to a further treatment before being discharged to the sewage treatment plant or before it can be re-used.

ADVANTAGES OF THERMAL TREATMENT OF WASTE WATER CONTAINING OIL:

- Max. concentration up to a water portion of < 5 % is possible
- Nearly complete separation of salts and heavy metals
- Clear reduction of the CSB value
- Addition of chemical substances and of auxiliary substances is not required
- No formation of additional sludge portions
- No risk of clogging and blocking of plant parts low operating and maintenance expenditure
- Low energy consumption with mechanical vapour recompression
- Insensitive to fluctuating inlet concentrations and compositions



Falling film forced circulation evaporation plant with mechanical vapour recompression. Evaporation rate: 9,000 kg/h



Waste Water Containing Oil and Salts, from Disposal Companies and from Tank and Barrel Cleaning

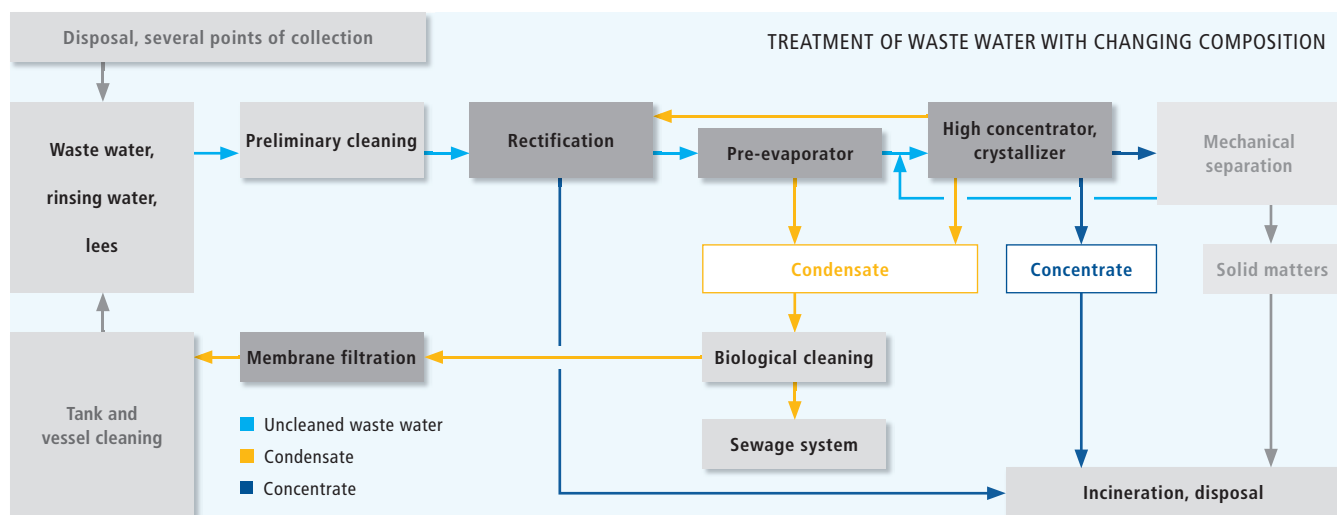
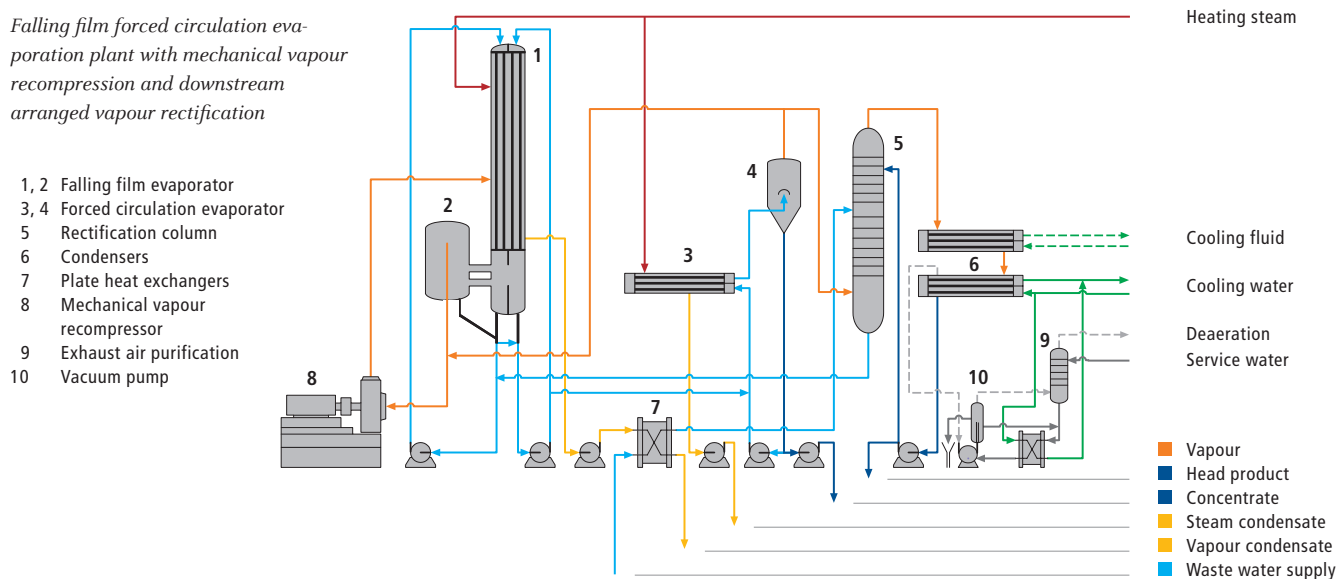
Waste water occurring in disposal companies have several origins and strongly vary regarding quantity and composition. Even with an appropriate pre-cleaning it is rarely possible to achieve a uniform waste water composition. The situation in barrel and vessel cleaning companies is similar. Rinsing and cleaning water produce effluents with continuously changing quantities of salts, oils, tensides, sludges, organic substances and heavy metals. A treatment system for such difficult waste waters must be extremely robust and flexible to comply with the varying requirements and simultaneously to ensure sufficient operating param-

eters. The best results can be achieved with thermal separation systems.

Process description

Falling film and forced circulation evaporators are used, if required with crystallization effect, for salt separation and rectification columns to strip volatile components. To optimize the operating costs, the design provides for a thermo-technical coupling of the different plant stages and with a multi-effect arrangement, thermal and mechanical vapour recompression the required energy consumption is reduced to a minimum.

Falling film forced circulation evaporation plant with mechanical vapour recompression and downstream arranged vapour rectification





Waste Water from Industrial Laundries

In many industrial areas, cleaning cloths are used to absorb greasy, oily or other fluid residuals. Apart from throw-away cleaning cloths, mainly cleaning cloths are used which can be washed and re-used.

In special washing machines tensides and cleaning agents are added to wash out the dirt. A washing water remains which is highly loaded, perhaps even with different solid matter portions of chips, abrasion particles and colour pigments.

It is the objective of the water treatment to clean the water as much as possible so that it can be re-used for the washing process. The portion of solid matters to be disposed should be as low as possible.

Process description

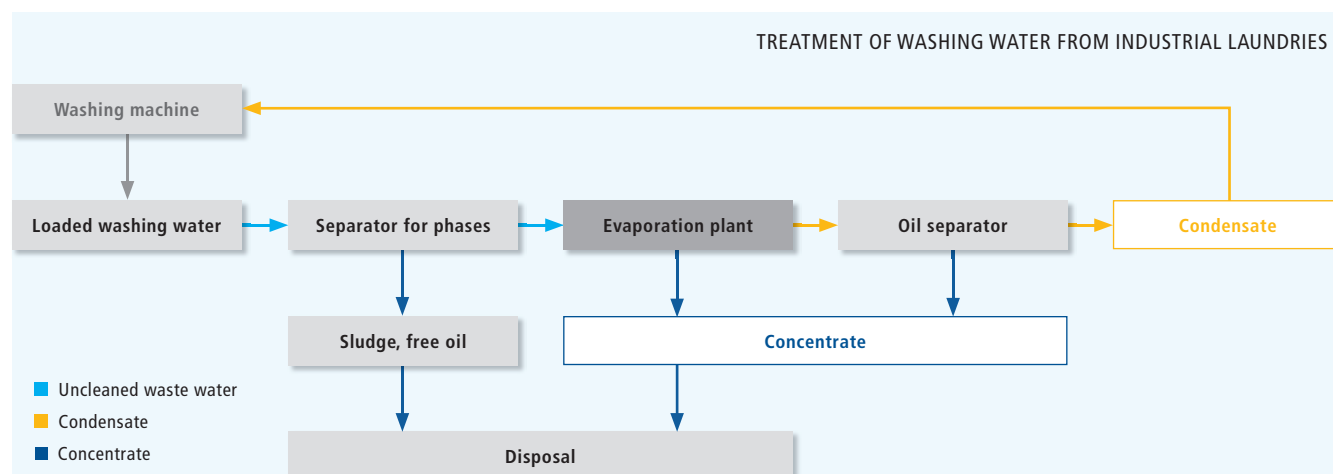
Free oils and sludge are roughly separated and supplied to the disposal unit for solid matters. The waste water is then further separated in an evaporation plant. The concentrate is disposed, the condensate is further prepared in an oil separator and is then returned to the washing machine. To save energy costs, a single-effect falling film evaporation plant with mechanical vapour recompression and a forced circulation evaporator for high concentration is used.



High-capacity fan for mechanical vapour recompression



*Falling film forced circulation evaporation plant with mechanical vapour recompression.
Evaporation rate: 11,000 kg/h*



Toxic Waste Water from Chemical Production Processes

In the production of plant pesticides, such as herbicides and fungicides, but also in other chemical processes waste water is produced which essentially consist of several organic components, and a considerable amount of salt and mainly of water. The treatment of these waste waters is very difficult because their toxicity hinders dumping. Disposal has to be achieved in an incineration plant. As the concentration of the ingredients in the waste water is relatively low, for cost reasons a concentration prior to incineration is recommendable. If necessary, the salt load has to be minimized. Both tasks can be optimally fulfilled with thermal separation systems.

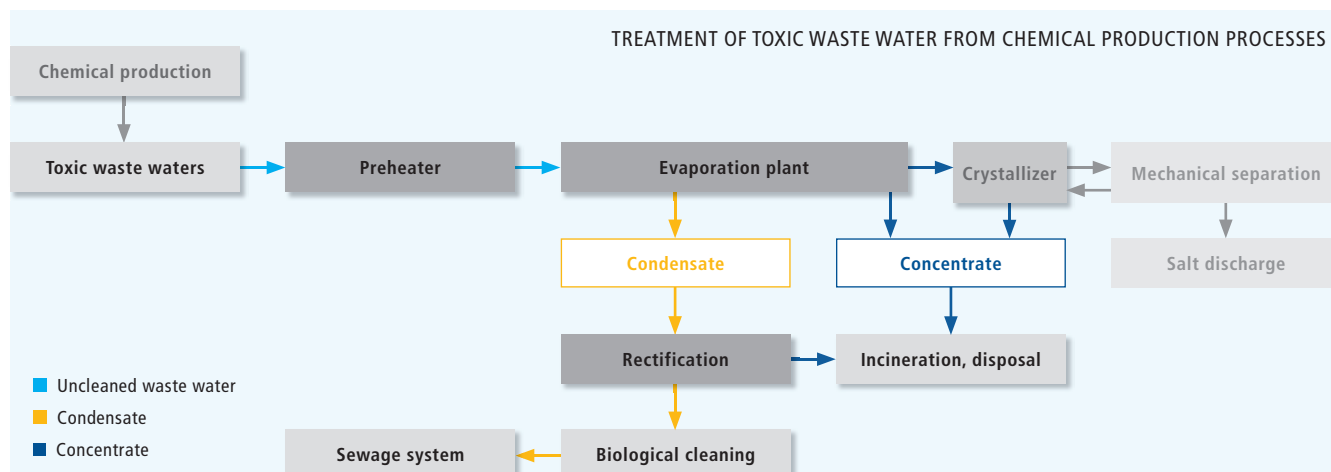
Process description

The major part of the water portion is evaporated in an evaporation plant. If you design the plant as an evaporation-crystallization plant or if you arrange a crystallization effect downstream of the pre-evaporation, an important portion of the salt freight can be separated in form of crystals. Subsequently, in a rectification column which potentially contains volatile organic components, they have to be removed from the vapour condensate. In this way, the waste water quantity to be incinerated is reduced to a relatively small concentrate quantity with a considerably increased organic portion.

These solutions are rather aggressive; therefore, not only the process engineering has to be clarified for the plant design, but also the material issue. If there is no experience for the material resistance, corrosion tests with the planned materials under the planned operating conditions are indispensable.



*Two-effect falling film forced circulation evaporation plant in counter-current arrangement, with downstream distillative cleaning of the vapour condensate.
Evaporation rate: 9,000 kg/h with a concentration to 65 % TS (dry substance)*



Waste Water from the Production of Wood Fibre Boards (MDF)

As raw material for the wood fibre board production, mainly round wood, chipped wood, slabs and saw dust is used. In the process of fibre board production, large quantities of organically loaded waste water occur. Depending on the process, they are strongly contaminated by wood ingredients, such as organic acids, saccharides, aldehydes and terpenes. With evaporation, an economical treatment of these waste waters is possible.

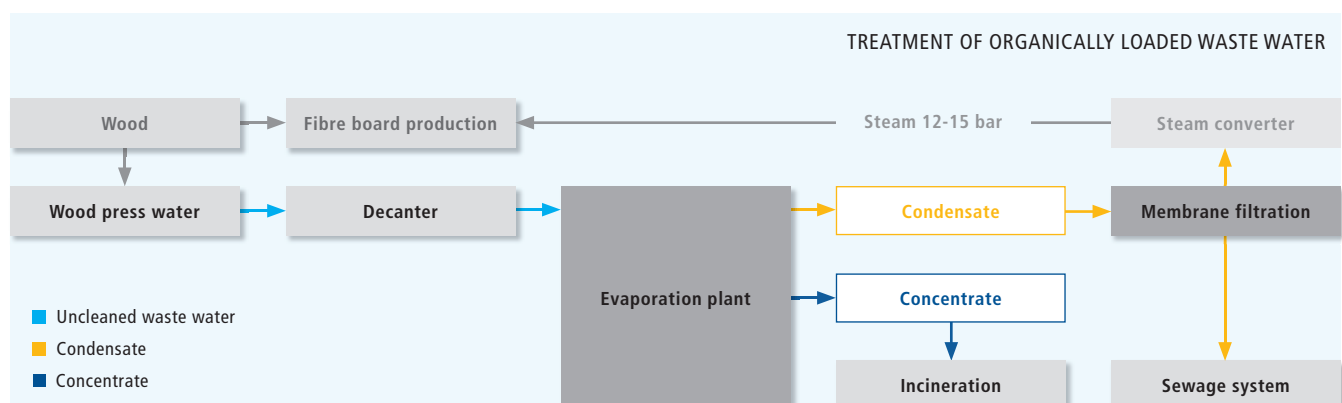
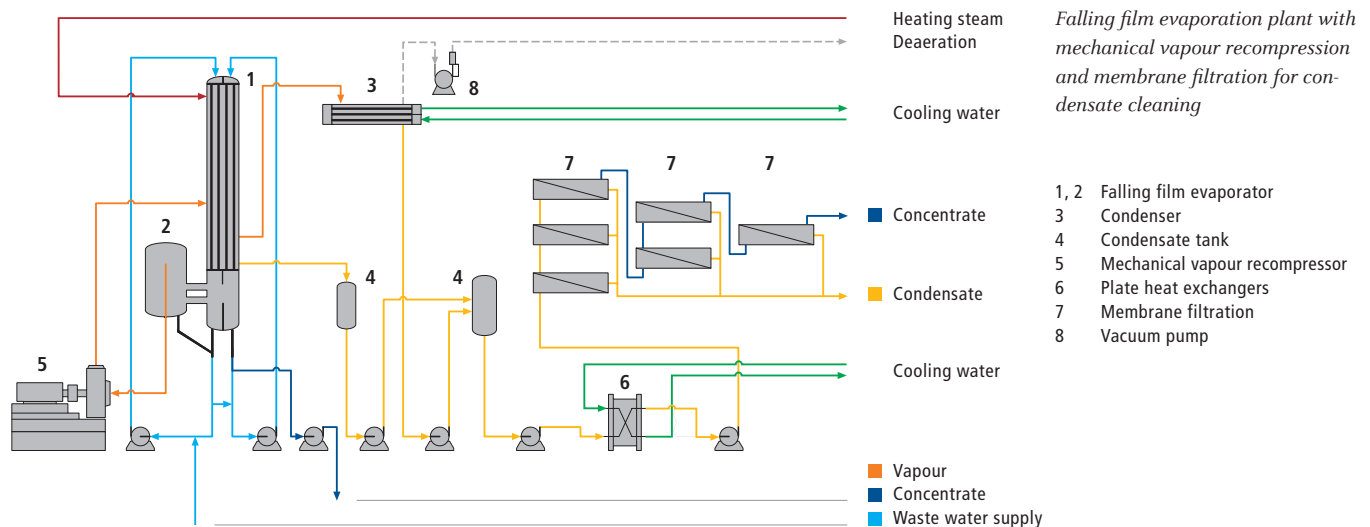
Process description

The waste water is concentrated in a falling-film evaporator. To achieve an increased concentration, a forced circulation evaporator can be arranged downstream. The condensates from the evaporator are still strongly loaded and have to be further cleaned in a membrane filtration plant before either being converted to low-

pressure steam in steam converters or before they can be discharged to the waste water system. The concentrate is incinerated in the combustion systems of the steam boilers. The plant layout largely depends on the available energy. The utilization of waste energy, such as dryer exhaust steam is optimal. If exhaust steam is not available, the heating by means of a mechanical vapour recompressor is very efficient.



Membrane filtration plant



Waste Water from Wood Steaming

In the wood-working industry, round and timber wood is steamed before and after the paring and sawing process. The steaming results in a modification and stabilization of the wood quality. During the steaming process, large quantities of slightly acidic condensate accumulate, a waste water which mainly contains organic acids and water-soluble wood polyoses. This condensate must be collected and disposed or treated.

For these applications, an evaporation has important advantages. The evaporated water (vapour) can be directly used for steaming, the concentrated harmful substances can be incinerated in the boiler systems for the generation of warm water and steam.

Process description

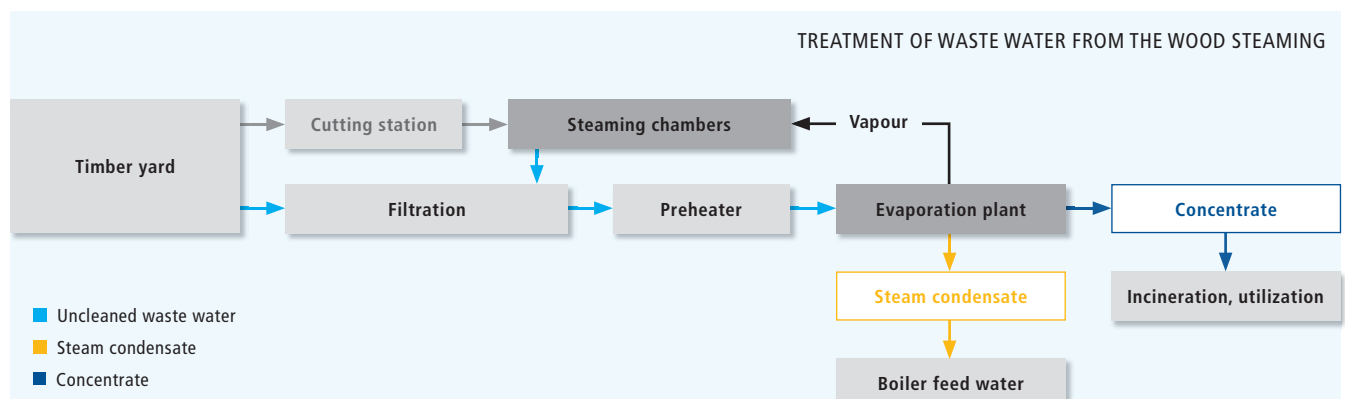
In a falling film evaporation plant, the steam condensate is concentrated to a large extent, to minimize the heating surface contamination a forced circulation evaporator is used for further evaporation. In this way, high concentrations can be achieved. The subsequent incineration is therefore more efficient. Apart from the highly thickened concentrate no other wastes are produced in evaporation. The vapour from the evaporation plant is conveyed directly into the steam chambers, the wood to be steamed practically acts as condenser. The collected condensate is returned into the evaporation plant where it is concentrated. The evaporation plant is directly heated by low-pressure steam. The heating steam condensate is returned to the steam boiler as boiler feed water.



Two-effect evaporation plant for wood steaming waste water. Evaporation rate: 5,000 kg/h

ADVANTAGES OF THE PROCESS:

- Highly concentrated, combustible wood steaming concentrate
- Conversion of waste water to steam for wood steaming
- Avoidance of waste water
- Long service life, high availability



Waste Water from Biotechnology

In large-scale biotechnological production processes, large quantities of waste water are produced. Depending on the process they are strongly contaminated and can neither be re-used without a prior treatment nor can they be introduced into the sewage system. Due to the strong contamination by organic substances and salts, in most of the cases a biological treatment is not efficient, or is too complex.

The contents of these waste water, however, are best suited for the production of fertilizers and fodder. For this purpose, the waste water is concentrated in an evaporation plant, and subsequently it is dried.

Process description

For large waste water quantities, mostly multi-effect falling film evaporation plants with forced circulation effects are used for high-concentration. Plant layout and type of heating decisively depend on the chemical-physical properties of the waste water and of the available utilities. The use of waste energy, such as dryer air, and the utilization of the evaporated vapour is optimal to heat the evaporator.

Depending on the purity, the condensate from the evaporation plant can be re-used in the production process. This represents an important contribution to the water management of the overall production. Excessive condensate can be discharged to a sewage system without any problems.

BIOTECHNOLOGICAL PROCESSES WITH LARGE WASTE WATER QUANTITIES:

- Yeast production
- Lysine production
- Glutamic acid production
- Drinking alcohol production
- Ethanol production



*Six-effect falling film forced circulation evaporation plant.
Evaporation rate 31,000 kg/h*

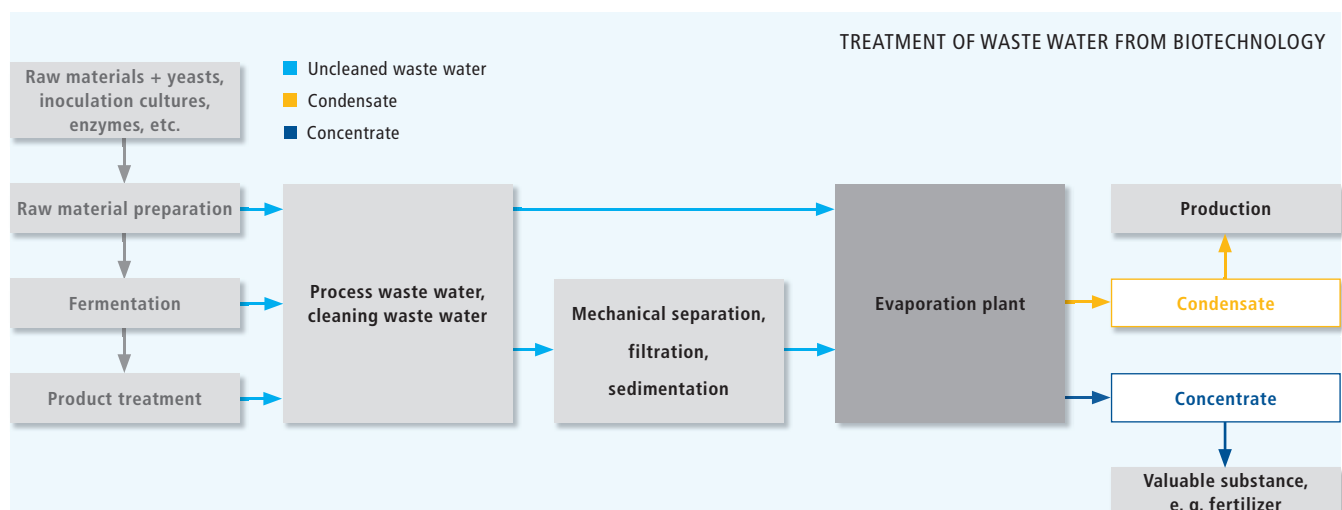
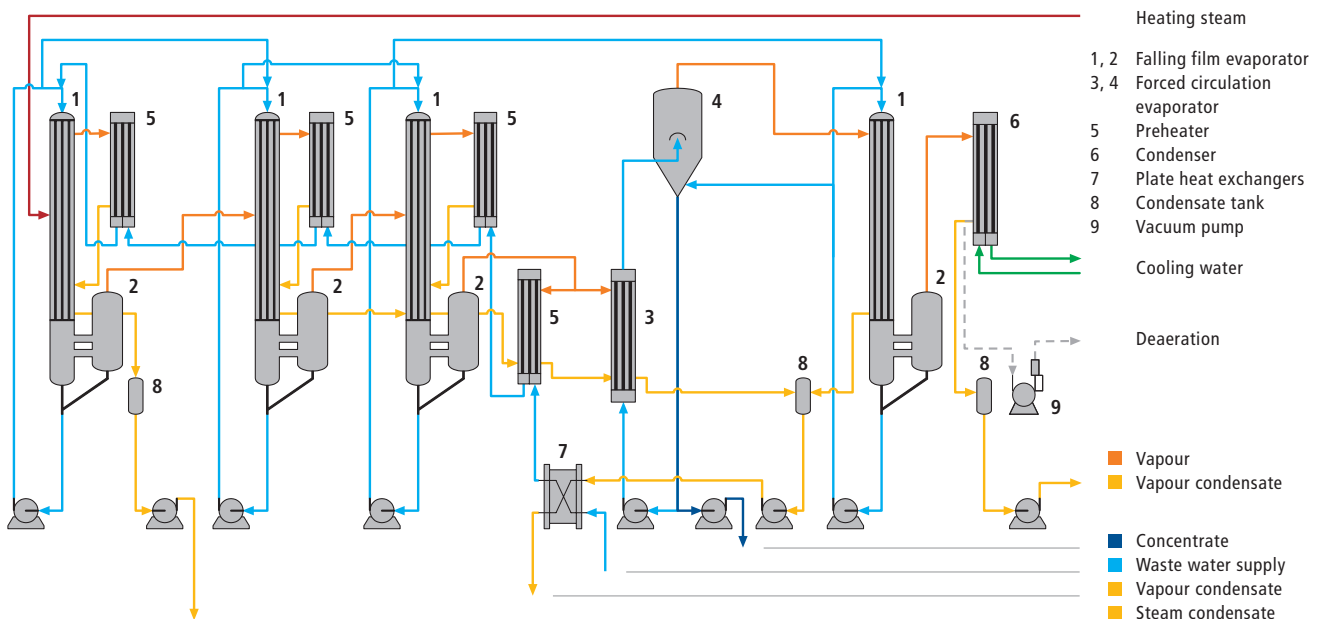


Figure (right): Two-effect falling film forced circulation evaporation plant with two mechanical vapour recompressors to concentrate waste water from lysine production. Evaporation rate 67,500 kg/h

Figure (centre): Layout of two five-effect falling film forced circulation evaporation plants for the concentration of waste water from monosodium glutamate production. Evaporation rate: $2 \times 120,000$ kg/h

Sketch (below): Five-effect falling film forced circulation evaporation plant, directly heated



Organic Waste Water from the Food and Starch Industry

For sanitary reasons, production plants in the food industry must be cleaned in regular intervals. The cleaning and rinsing water is organically strongly loaded.

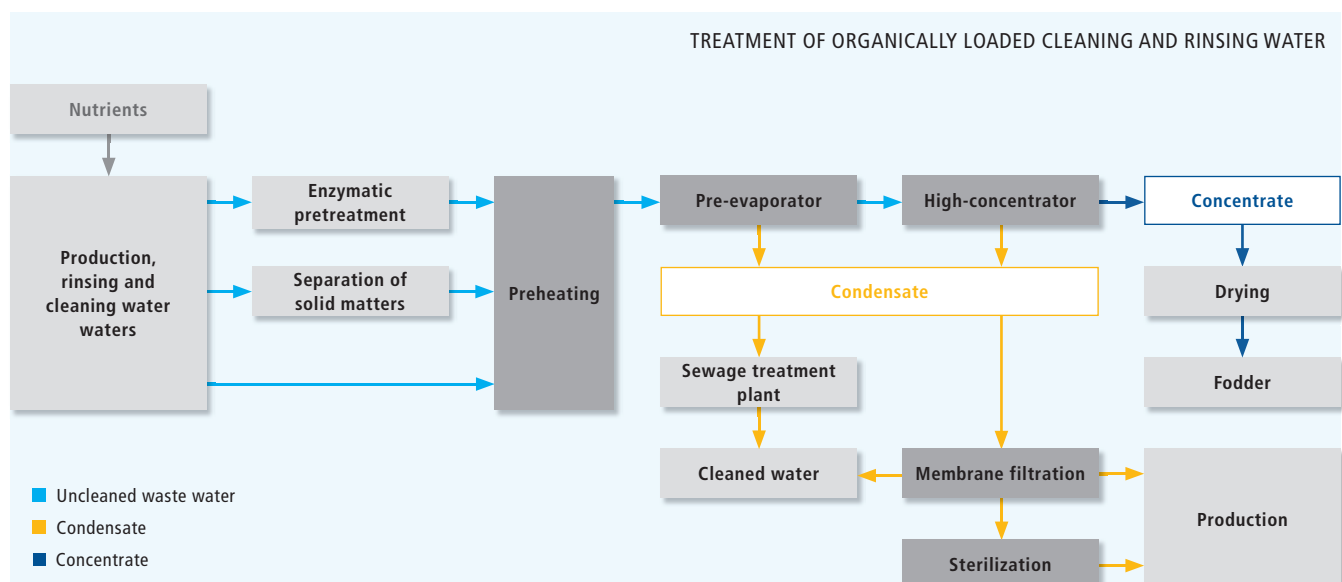
In starch production, large quantities of washing and spring water occur during the processing of raw materials.

All these waters still contain valuable nutrients, such as proteins and lactic acid which can be further used in the production of fodder.

Waste water evaporation is a well-proven process to concentrate the ingredients and to recover the water portion in form of vapour condensate. Depending on the requirements to the final product and on the water quality, evaporation is combined with mechanical pre-separation, enzymatic treatment, concentrate drying, thermal sterilization and membrane filtration.



*Concentration of potato juice
Two pre-evaporators with mechanical vapour recompression
and a finisher with thermal vapour recompression.
Evaporation rate in total: 152,000 kg/h*



Process description

The waste water is pretreated and then conveyed to the evaporation plant. Pre-concentration and main evaporation take place in a falling film evaporator. The required final concentration is achieved in a downstream forced circulation evaporator. The evaporation plant can be designed as one-effect or as multi-effect unit, it can be heated by steam or by a thermal vapour recompressor. Plants with mechanical vapour recompressor are particularly energy-saving.

With this plant design, high final concentrations and long operating periods of the overall plant can be achieved.

The vapour condensates are used to preheat the product feed. If returned into the production process, they are treated again, if required, and sterilized.

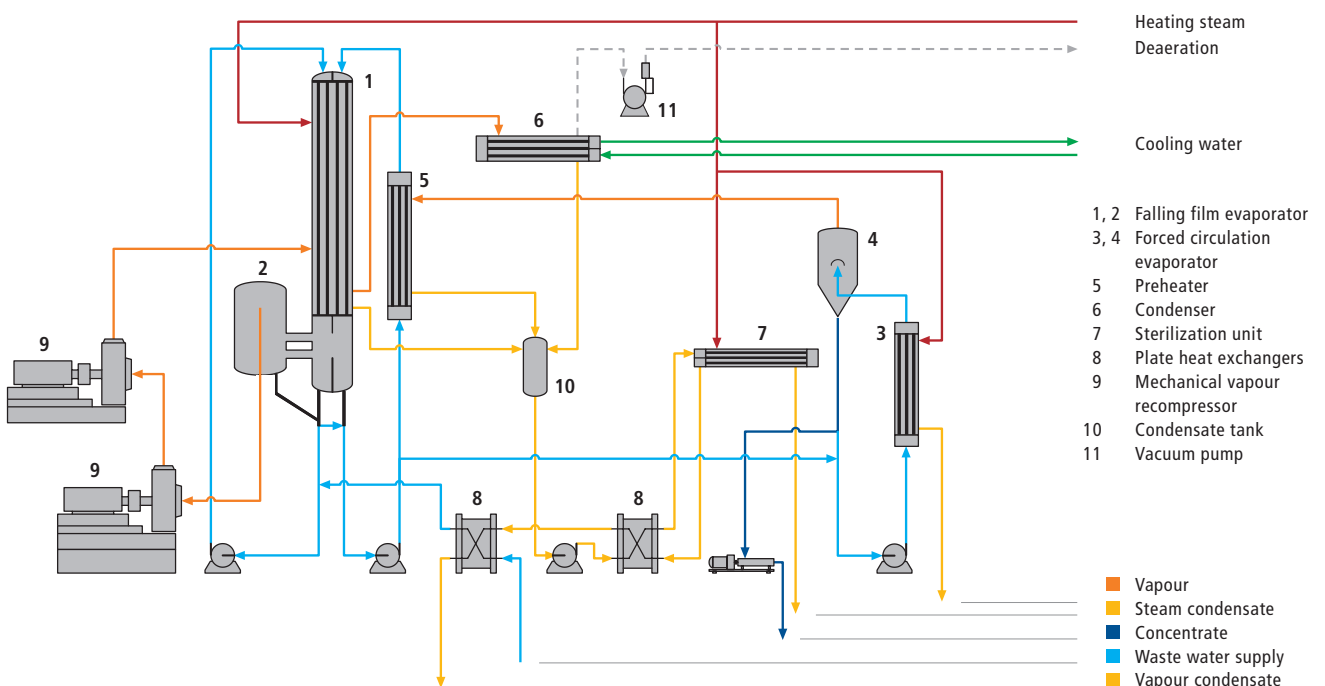
ADVANTAGES OF THE PROCESS:

- Stable operation, independent of the composition of the waste water
- Cost-efficient operation thanks to the utilization of mechanical vapour recompression
- Relieve of the conventional biological waste water treatment
- Conversion of waste water to process water
- Recovery of precious fodder



Process control room of a multi-effect fully automated evaporation plant

Falling film pre-evaporator with mechanical vapour recompression and forced circulation finisher, combined with thermal sterilization of the vapour condensate



Waste Water from Olive Oil Production

Waste water from olive mills is highly loaded by organically substances. In the Mediterranean countries, the centre of olive oil production, this causes important environmental problems. In most of the cases, it is collected in evaporation ponds or it is directly supplied to the receiving water channel. Detrimental odours and dark, nearly black discolouration of the waters is the result. Moreover, the groundwater could be contaminated. The toxicity of the contained polyphenoles aggravates the treatment of olive mill waste waters in sewage treatment systems and the irrigation of fields.

Process description

The mixture of solid and liquid residuals is de-watered in a decanter, during this process, again olive oil is recovered. The concentrate (waste water) is supplied to the evaporation plant. The main components of the evaporation plant are a falling-film evaporator and a forced circulation evaporator as high concentrator.

The vapour condensate of the evaporation plant is further cleaned in a membrane filtration plant and can then be used as process water.

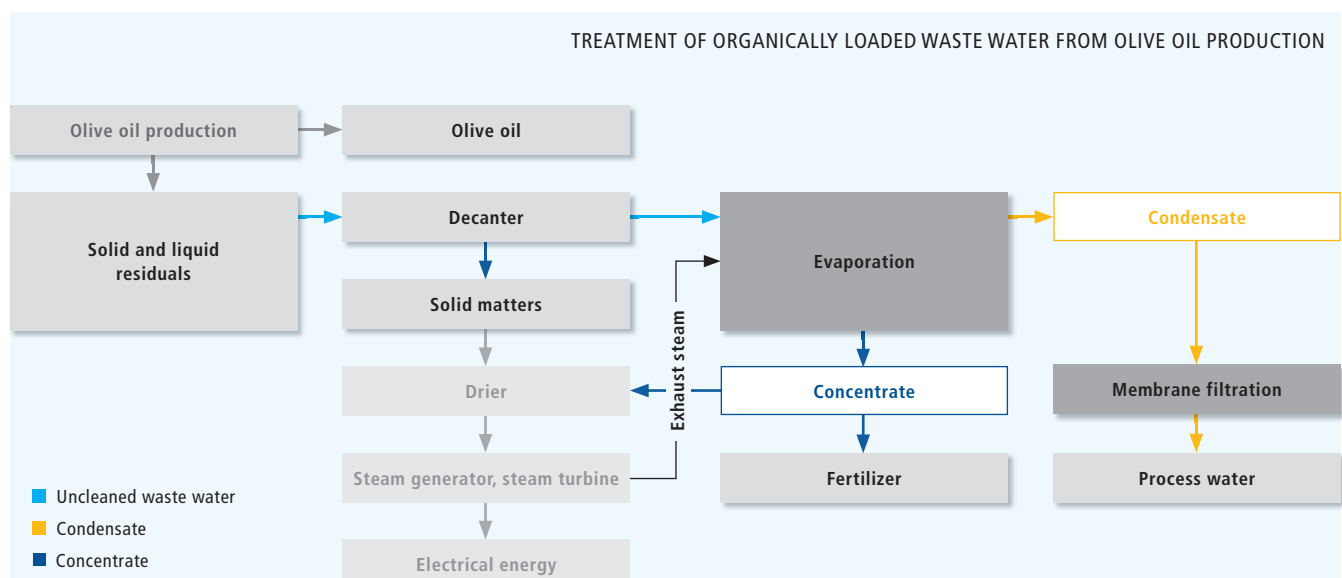
The concentrate and the solid matters are dried and supplied to a steam generator as fuel. The generated steam drives a turbine. The electrical power generated by a generator is supplied to the public mains. Part of the turbine exhaust steam is used to heat the evaporation plant, thus minimizing its operating costs. The evaporation of the olive mill waste water has proved to be a well functioning solution.

ADVANTAGES OF THE PROCESS:

- Stable operation, independent of the composition of the waste water
- Cost-efficient operation thanks to the utilization of waste energy
- Generation of electrical energy from waste products
- Conversion of the waste water to process water
- Recovery of precious fertilizer



*Falling film forced circulation evaporation plant, directly heated by turbine exhaust steam
Evaporation rate: 31.000 kg/h*



Fermentation Residuals from the Bio-gas Production

Raw materials for bio-gas production are so-called fermentation substrates, such as corn, grain and grass, stillage from distilleries, manure, biological waste, remains of food and other fermenting residuals. After the anaerobic fermentation there are fermentation residuals, a mixture of persistent organic substances. The disposal of these fermentation residuals is decisive for the cost-efficiency of a bio-gas plant. Its storage and its transport to agricultural areas is cost-intensive since the produced fermentation residuals are large (water contents 90 - 95 %).

Evaporation strongly reduces the quantity of fermentation residuals and therefore contributes to a solution of these problems to a large extent. The efficiency of evaporation will be particularly high if waste energy sources, such as vapour from a drying process or hot water from gas motor cooling can be used as heating medium.

Process description

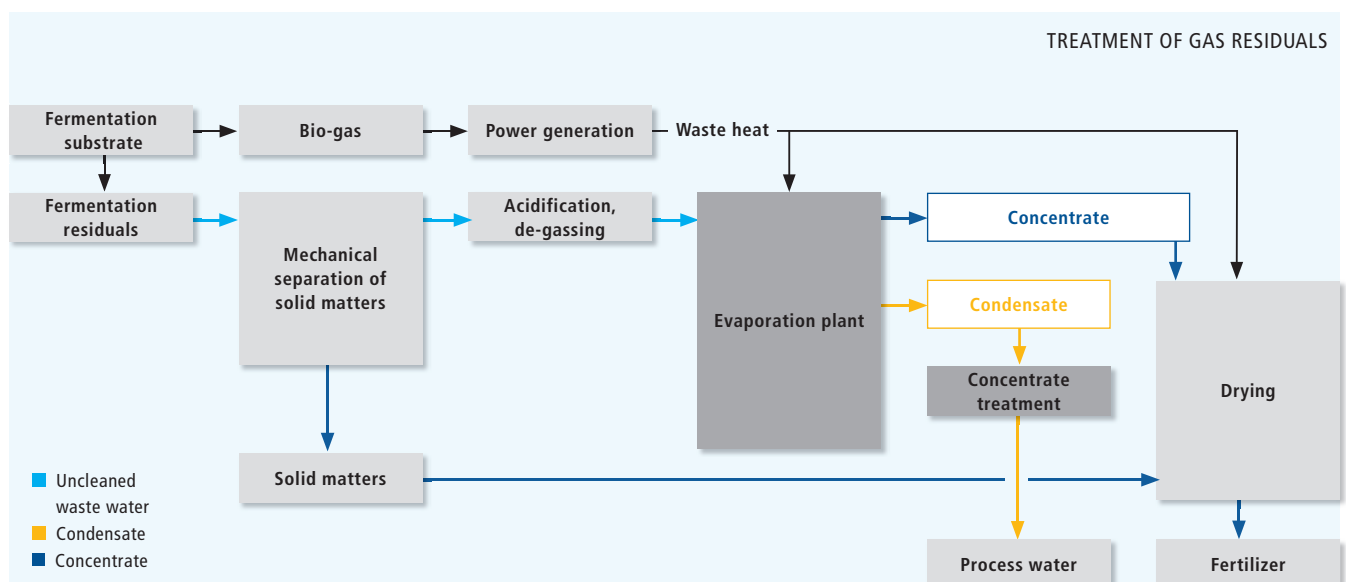
The fermentation residuals are de-watered in decanter centrifuges. The phase with high portion of solid matters is supplied to the drier. After acidification and de-gassing, the liquid phase is evaporated. The concentrate of the evaporation plant is dried together with the solid matters from the decanter. The vapour condensate is further cleaned in a membrane filtration plant or in an alkaline water scrubber, and can then be used as process water. The energy for the plant operation comes from small de-centralized block heating power stations. Electrical energy is generated by gas motors from bio-gas and natural gas. The occurring waste heat is used as energy source for the evaporation and drying process.

ADVANTAGES OF THE PROCESS:

- Cost-efficient operation thanks to the utilization of waste energy
- Generation of electrical energy from waste products
- Conversion of the waste water to process water
- Recovery of precious fertilizer



*Two-effect forced circulation
evaporation plant
Evaporation rate: 12,000 kg/h*



Overview of our Scope of Delivery

Evaporation plants

for the concentration of any type of liquid food, organic and inorganic solutions, waste water and other fluid products; in one-effect or multi-effect design, by means of thermal or mechanical vapour recompression, with additional equipment for heating, cooling, degassing, crystallization, rectification.

Membrane filtration – GEA Filtration

for the concentration of fluid food, process water, organic and inorganic solutions and waste water, as well as for the separation of contaminations for the improvement of quality and for the recovery of valuable substances.

Distillation / rectification plants

for the separation of multi-component mixtures, for the recovery of organic solvents, the recovery, cleaning and dehydration of bio-alcohol of different qualities.

Alcohol production lines

from raw material preparation, fermentation, distillation and stillage processing up to steam drying.

Crystallization plants

for special products and waste waters containing salts.

Case studies, engineering

for plants of our scope of delivery.



Process Engineering

GEA Wiegand GmbH

Am Hardtwald 1 · D-76275 Ettlingen, Germany

Tel.: +49 7243 705-0 · Fax: +49 7243 705-330

gea-wiegand.info@gea.de · www.gea-wiegand.com