

INDUSTRIAL WASTEWATER

Creating value from waste
using thermal separation technology



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Creating value from waste.

At GEA, we are committed to creating environmentally compatible and efficient, value-adding solutions for the treatment of industrial effluent flows

Effluent flows that come from production or such as are generated as the result of purification processes increasingly present great challenges to industrial companies.

For the environmentally compatible treatment of these effluents, GEA supports industry with innovative process technology and first-class equipment that is both reliable and efficient for treatment of the effluent contamination.

This allows not only a lasting reduction in corresponding disposal costs: the recovery of valuable content from the production flows also makes a considerable contribution to significant cost savings.

By transforming waste into valuable products and energy, thermal separation not only addresses waste management challenges but also contributes to economic and environmental sustainability.

Thermal separation can significantly contribute to creating value from waste through various processes:

- **Volume reduction**

Significantly reduces the volume of waste, decreasing the need for landfill space and associated costs.

- **Resource recovery**

Reduces waste management costs by minimizing waste volume and recovering valuable resources.

- **Environmental benefits**

Diverts liquid waste streams, promoting a circular economy and reducing environmental impact.

- **Economic benefits**

Creates new revenue streams from the sale of recovered energy and materials.

- **Energy recovery**

The heat produced can be used for industrial processes, reducing reliance on fossil fuels.

EVAPORATION – THERMAL SEPARATION

GEA has been supporting the food, beverage and chemical industry in thermal separating duties for decades.

Evaporation Technology

Evaporation plants are required whenever water or any other liquid needs to be removed, concentration must be increased or volume reduced, in an industrial process.

To meet any spectrum of specifications and requirements, GEA designs plant solutions by offering various evaporator types, plant layouts, and heating options.

Each evaporator type and heating option offers distinct benefits. The most suitable combination is selected for each project based on the main process parameters.

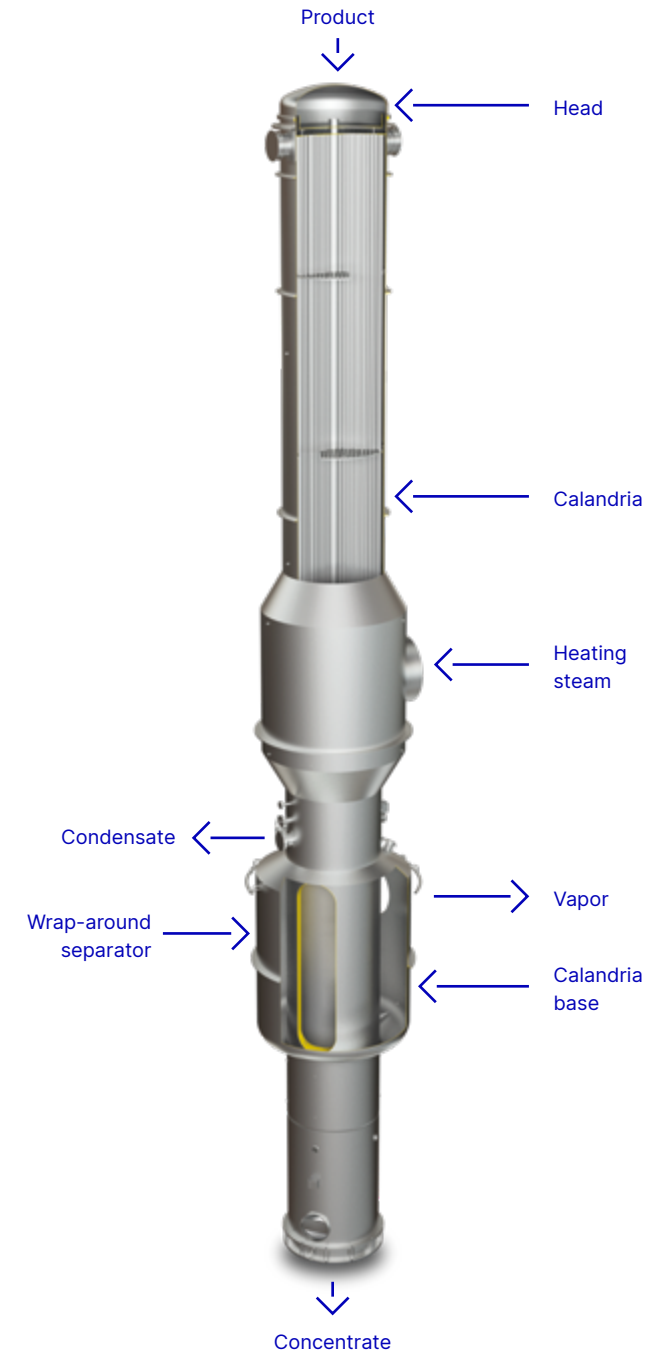
Particular features

- Best product quality
- High energy efficiency
- Waste heat utilization
- Simple process control and automation
- Flexible operation

Functional principle

The liquid to be concentrated is fed to the top of the heating tubes and distributed so that it flows down as a thin film on the inside of the tube walls. The liquid film begins to boil due to the external heating of the tubes and is partially evaporated. The downward flow, initially caused by gravity, is enhanced by the parallel downward flow of the vapor formed. Residual liquid film and vapor are separated in the lower part of the calandria and in a wrap-around, monobloc-type, or laterally arranged centrifugal separator.

It is essential that the entire heating surface, especially in the lower regions, is evenly and sufficiently wetted with liquid. If this is not achieved, dry spots will form, leading to incrustation and deposit buildup. GEA plants ensure complete wetting by carefully selecting a suitable distribution system for the evaporator head. Wetting rates are increased by using longer heating tubes, dividing the evaporator into several compartments, or recirculating the product.



APPLICATIONS - PROCESS & WASTEWATER

Chemical industry

- Fiber board (MDF) effluent
- Wastewater containing volatile and salts
- Pesticide / herbicide production processes
- Caprolactam production process
- Oil-water emulsions

Food & Beverage

- Effluent from coffee production
- Effluent from plant based beverages

Environmental industry

- Zero liquid discharge (ZLD)
- Starch effluents

Fermentation products

- Processing fermentation products
- Biotechnology
- Fermentation residuals from biogas



Fiber board (MDF) effluent treatment & water recycling

Close the water loop in your fiber board production with our innovative 3-stage water treatment solution.

Application

In the process of fiber board production, large quantities of organically loaded wastewater occur. Depending on the process and the raw material, they are strongly contaminated by wood ingredients, such as organic acids, saccharides, aldehydes and terpenes. In a combination of mechanical separation and evaporation, an economical treatment and recycling of these wastewaters is possible.

Advantages

- Maximum energy efficiency
- Electrified evaporator (heat pump principle)
- Recycled process condensate
- Reduced water consumption
- Optimized solids separation
- Vacuum evaporation at low temperatures
- Long operation period
- Minimum use of chemicals
- Fully automatic operation
- Easy and automatic cleaning
- Minimal pressure difference

Process description

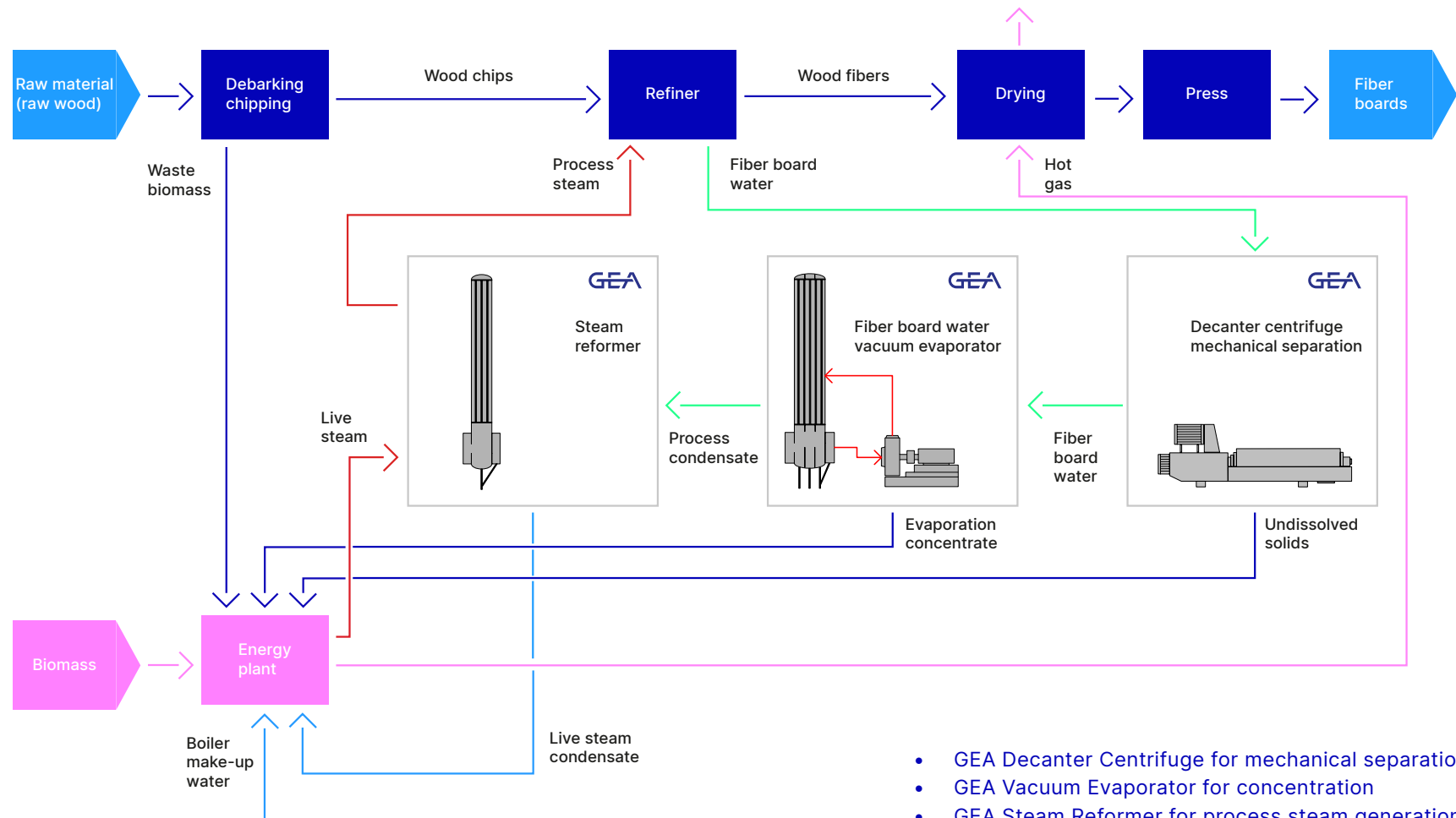
Our process includes three different process steps to ensure maximized water savings and energy efficiency:

- The first stage comprises mechanical separation with GEA decanter centrifuges. Here, suspended solids are effectively removed from the wastewater stream.
- The second stage is the thermal separation with the GEA falling film evaporator. Here, dissolved solids are concentrated for their later disposal, while clear condensate is produced to feed the third stage. This stage is especially sustainable thanks to the mechanical vapor recompression (MVR) system that powers the evaporator.
- The third stage consists of our steam reformer. This stage gives full circularity to the water recycling system. It catches wastewater in a loop where it transforms into process steam. Using wastewater instead of fresh boiler feed water to produce process steam allows significant water and cost savings.

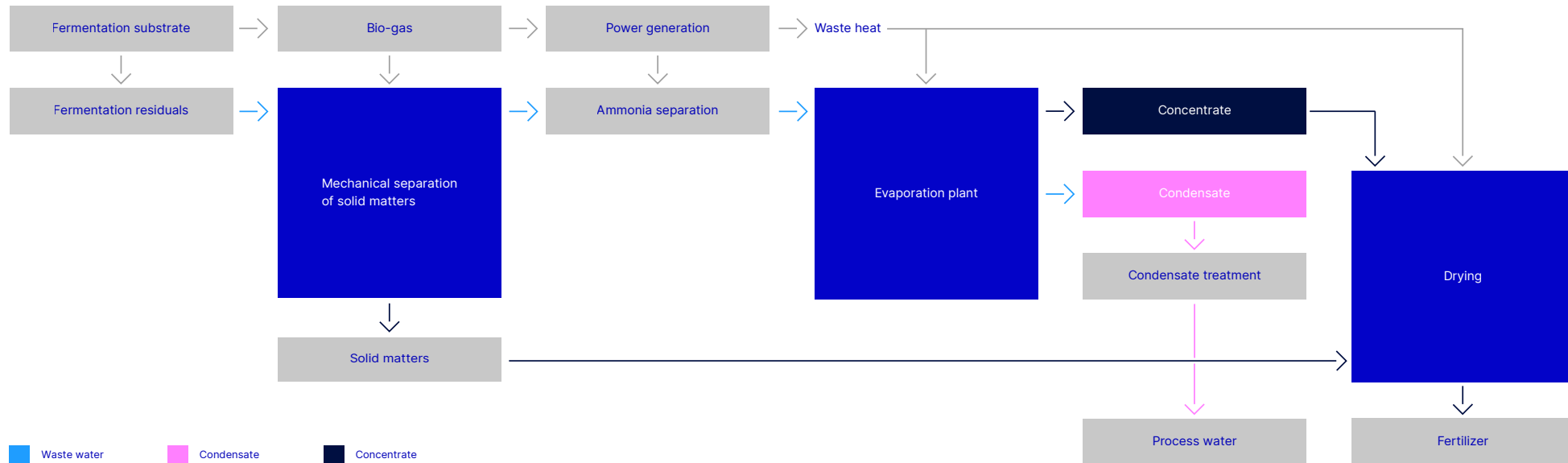


Closing the water treatment loop

Wastewater treatment from the production of wood fiber boards (MDF)



Fermentation residuals from biogas



Application

Raw materials for biogas production include fermentation substrates such as corn, grain, grass, distillery stillage, manure, biological waste, food remains, and other fermenting residues. After anaerobic fermentation, a mixture of persistent organic substances remains. The disposal of these fermentation residues is crucial for the cost-efficiency of a biogas plant. Storage and transport to agricultural areas are cost-intensive due to the high water content (90-95%) of the fermentation residues. Evaporation significantly reduces the quantity of these residues, offering a substantial solution. The efficiency of evaporation is particularly high when waste energy sources are used.

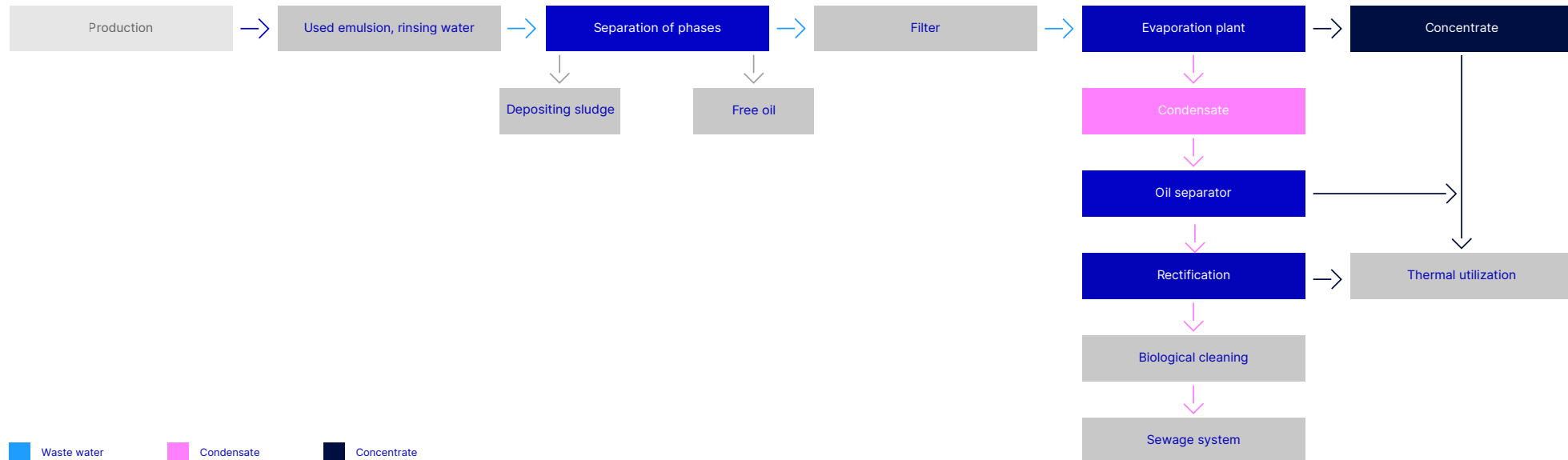
Advantages

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

Process description

The fermentation residues are dewatered in decanter centrifuges. The solid-rich phase is sent to the dryer. After ammonia separation, the liquid phase is evaporated. The concentrate from the evaporation plant is dried together with the solids from the decanter. The vapor condensate is further cleaned in a membrane filtration plant or an alkaline water scrubber and can then be used as process water. Energy for the plant operation is supplied by small decentralized block heating power stations. Electrical energy is generated by gas motors running on biogas and natural gas, and the resulting waste heat is utilized as an energy source for the evaporation and drying processes.

Oil-water emulsions



Application

In the metal-working industry, oil-water emulsions are used as cooling agents and lubricants. After undergoing expensive regeneration processes, they can be reused multiple times, but eventually, they must be replaced. The goal of treatment is to separate the oily substances from the watery portions. The water contamination should be minimized before it is either discharged to a sewage treatment plant or reused in the factory, while the oily content should be highly concentrated and transferred to an incineration plant. Thermal separation in an evaporation plant can achieve this.

Advantages

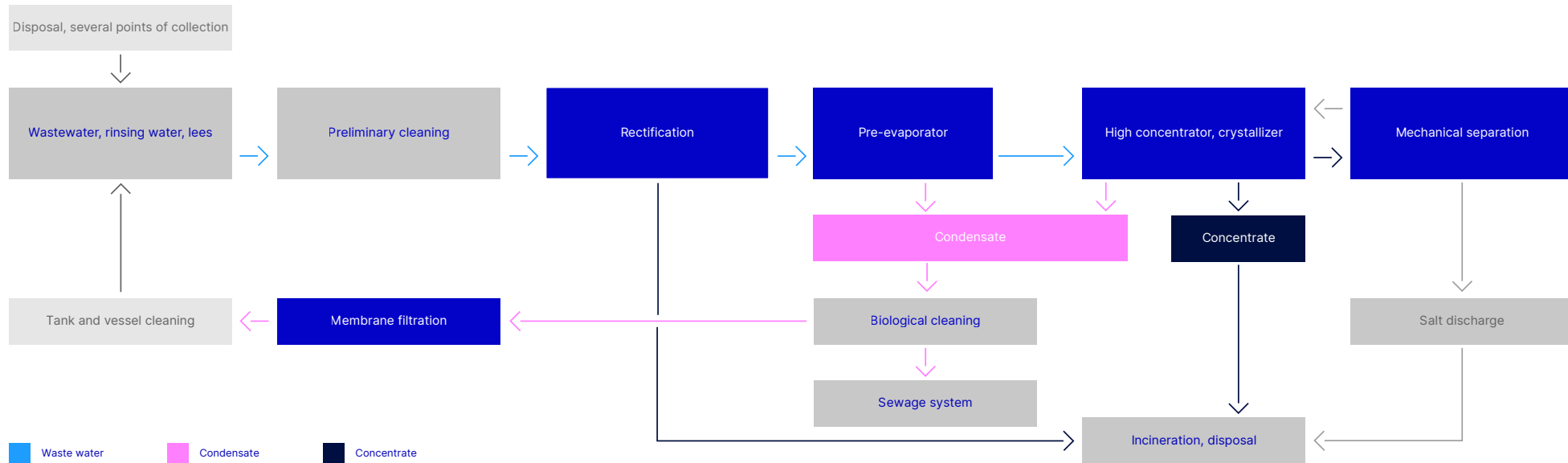
- Maximum concentration up to less than 5% water
- Nearly complete separation of salts and heavy metals
- Significant reduction of chemical oxygen demand (COD)
- No need for the addition of chemical substances
- No formation of additional sludge
- No risk of clogging or blocking of plant parts
- Insensitive to fluctuating inlet concentrations and compositions

Process description

Coarse solid matter and free oils are first separated, and the wastewater is filtered again before being conveyed to the evaporation plant. The wastewater is concentrated to approximately 30% in a falling film pre-evaporator, which is heated by mechanical vapor recompression, an energy-saving process. High concentration is then achieved in a forced circulation evaporator.

In most cases, the vapor condensate still contains oil and requires further treatment before being discharged to the sewage treatment plant or reused.

Wastewater containing volatile and salts



Application

Wastewater generated by disposal companies comes from various sources and varies greatly in quantity and composition. Even with appropriate pre-cleaning, achieving a uniform wastewater composition is rarely possible. This is also true for barrel and vessel cleaning companies, where rinsing and cleaning water result in effluents with varying amounts of salts, oils, surfactants, sludges, organic substances, and heavy metals.

A treatment system for such challenging wastewater must be extremely robust and flexible to meet varying requirements while ensuring sufficient operating parameters. Thermal separation systems achieve the best results for this purpose.

Advantages

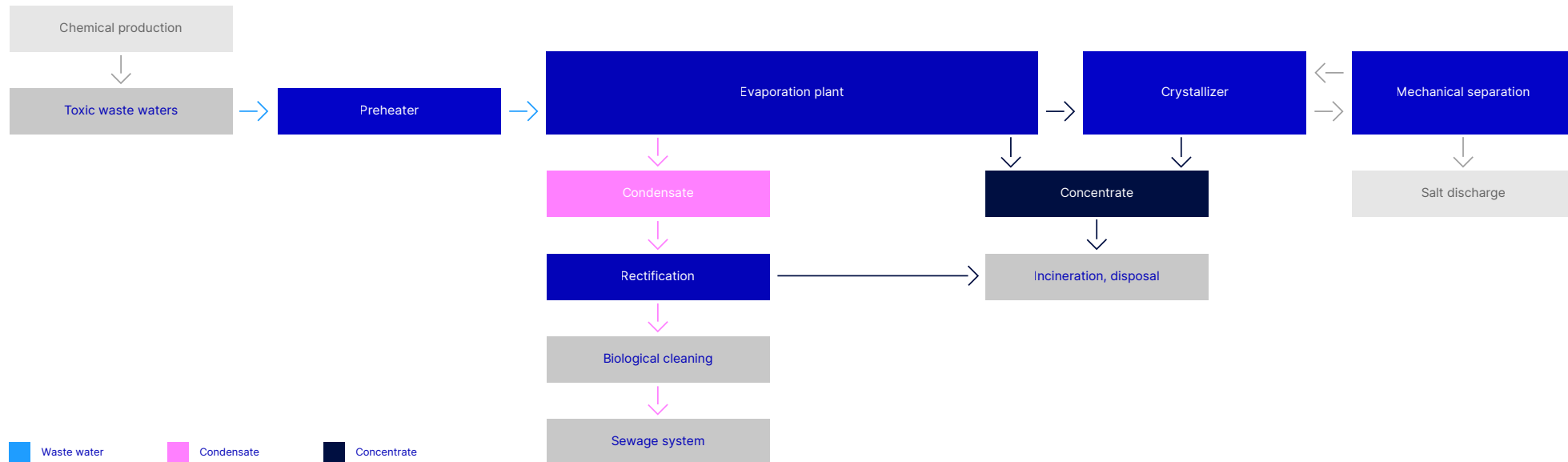
- Nearly complete separation of salts and volatiles
- Separate discharge of salt and volatiles
- Use of volatiles in incineration / valorisation
- Electrical solution for concentration and crystallization in many cases possible

Process description

Falling film and forced circulation evaporators are utilized, sometimes with a crystallization effect for salt separation, and rectification columns to strip volatile components.

To optimize operating costs, the design incorporates thermo-technical coupling of different plant stages. With a multi-effect arrangement and thermal and mechanical vapor recompression, the required energy consumption is minimized.

Pesticide/herbicide production processes



Application

In answer: In the production of plant pesticides, such as herbicides and fungicides, as well as in other chemical processes, wastewater is produced that consists primarily of several organic components, a considerable amount of salt, and mainly water. Treating this wastewater is challenging due to its toxicity, which prevents straightforward disposal. Instead, it must be incinerated. Given the relatively low concentration of ingredients in the wastewater, it is cost-effective to concentrate it before incineration. If necessary, the salt content must also be minimized. Both these tasks can be effectively achieved using thermal separation systems.

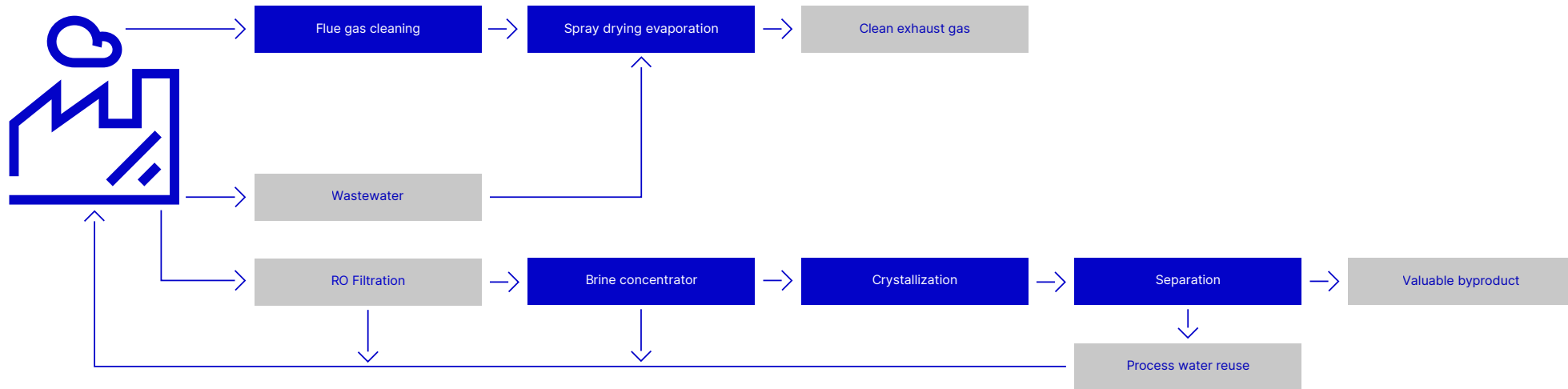
Advantages

- Nearly complete separation of salts and volatiles
- Separate discharge of salt and volatiles
- Use of volatiles in incineration / valorisation
- Electrical solution for concentration and crystallization in many cases possible

Process description

The majority of the wastewater is evaporated in an evaporation plant. Designing the plant as an evaporation-crystallization unit, or incorporating a crystallization effect downstream of the pre-evaporation, allows a significant portion of the salt to be separated as crystals. Subsequently, a rectification column is used to remove any volatile organic components from the vapor condensate. This process reduces the volume of wastewater to be incinerated to a relatively small, highly concentrated quantity with an increased organic content. These solutions are rather aggressive, so the plant design must address both process engineering and material selection. If there is no prior experience with the material resistance, conducting corrosion tests with the planned materials under the intended operating conditions is essential.

Zero liquid discharge



Application

Reduce end-of-pipe streams and increase values. Zero liquid discharge (ZLD) technology provides an efficient and environmentally friendly effluent processing system that improves in-plant water reuse, enhances product recovery and converts a fluid discharge to non-liquid waste. GEA is a single-source supplier of cost-effective, energy efficient and reliable wastewater treatment systems and emission control solutions.

Advantages

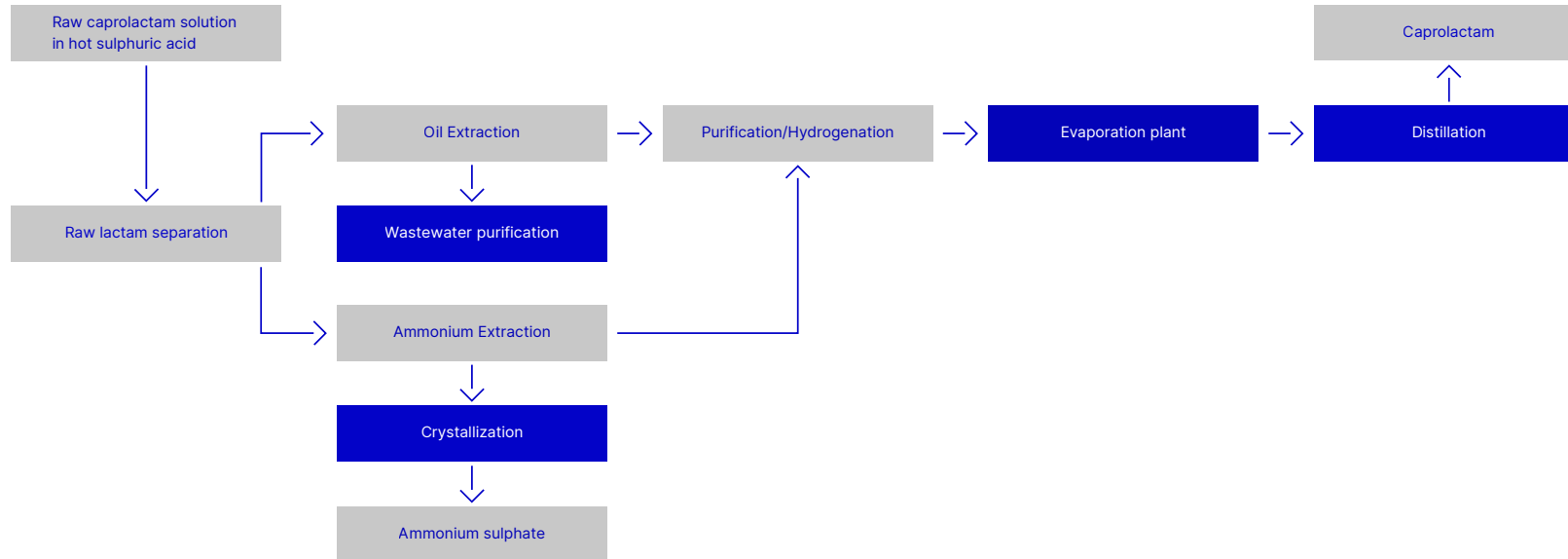
- ZLD is beneficial to the environment by minimizing wastewater discharge, increasing water reuse and recycling valuable products
- Energy-efficient operation
- Corrosion-resistant materials
- Variable waste flows
- Limited cleaning requirements
- Advanced automation systems

Process description

GEA's specialized evaporation and crystallization technologies are custom designed to meet the unique needs of our industrial process customers and facilitates the use of complementary operations such as precipitation, centrifugal clarification and drying.

Ensuring effective water management improves overall plant efficiency, saves operating costs and eliminates liquid waste streams, thereby protecting the environment.

Caprolactam production processes



Application

In the main production process, the in water dissolved caprolactam is evaporated to a concentration of about 90% in a multiple-effect evaporation plant.

The vapor condensate is recycled back into the process.

One side stream process involves the concentration of wastewater from oil extraction by evaporation, while another involves the crystallization of ammonium sulfate.

Advantages

- Maximum concentration up to less than 5% water
- Nearly complete separation of salts and heavy metals
- Significant reduction of chemical oxygen demand (COD)
- No need for the addition of chemical substances
- No formation of additional sludge
- No risk of clogging or blocking of plant parts
- Low operating and maintenance costs
- Low energy consumption with mechanical vapor recompression
- Insensitive to fluctuating inlet concentrations and compositions

Process description

Coarse solid matter and free oils are first separated, and the wastewater is filtered again before being conveyed to the evaporation plant. The wastewater is concentrated to approximately 30% in a falling film pre-evaporator, which is heated by mechanical vapor recompression, an energy-saving process. High concentration is then achieved in a forced circulation evaporator.

In most cases, the vapor condensate still contains oil and requires further treatment before being discharged to the sewage treatment plant or reused.

EVOLUTION OF ENERGY EFFICIENCY

Mechanical vapor recompression (MVR) reduces both energy costs and the carbon footprint and consequently, the environmental load.

Thermal separation processes, such as evaporation, are energy-intensive. In the course of its development, the aim to efficiently use this energy and reduce costs first led to single-effect plants heated by live steam, then to multiple-effect plants, then to thermal vapor recompression, and finally to the use of mechanical vapor recompression systems.

In conventional evaporation plants, the energy content of the vapor stream produced is either lost or only partially reused. In comparison, mechanical vapor recompression allows the continuous recycling of this energy stream by recompressing the vapor to a higher pressure and, therefore, a higher temperature. The compressed vapor can be used to heat the shell side of the evaporator. Instead of live steam, electric energy is used indirectly to heat the plant.



Advancements in thermal separation processes

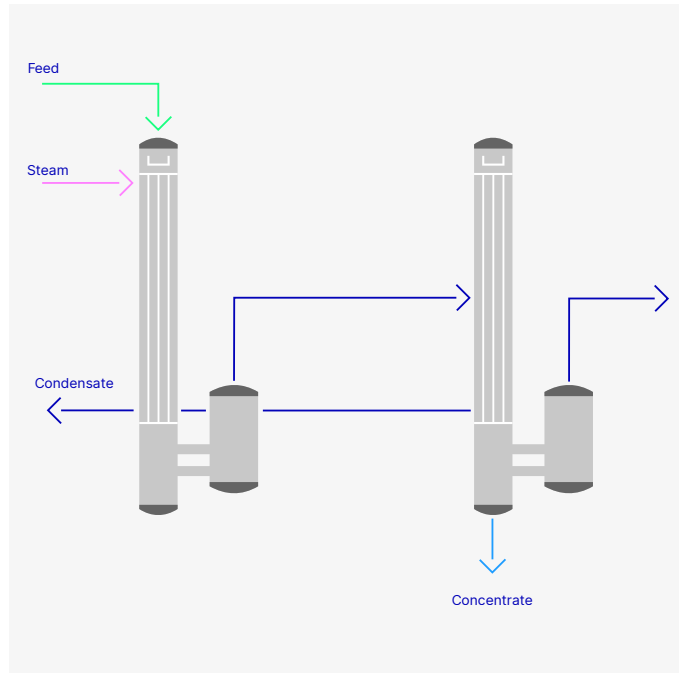


Fig. 1: Multi-effect evaporation plant, heated with direct steam

In a single-effect evaporator, the heat content (enthalpy) of the evaporated vapor is approximately equal to the heat input on the heating side. In the case of water evaporation, about 1 kg/h of vapor will be produced by 1 kg/h of live steam, as the specific evaporation heat values on the heating and product sides are about the same. If the amount of vapor produced by primary energy is used as heating steam in a second effect, the energy consumption of the overall system is reduced by about 50%.

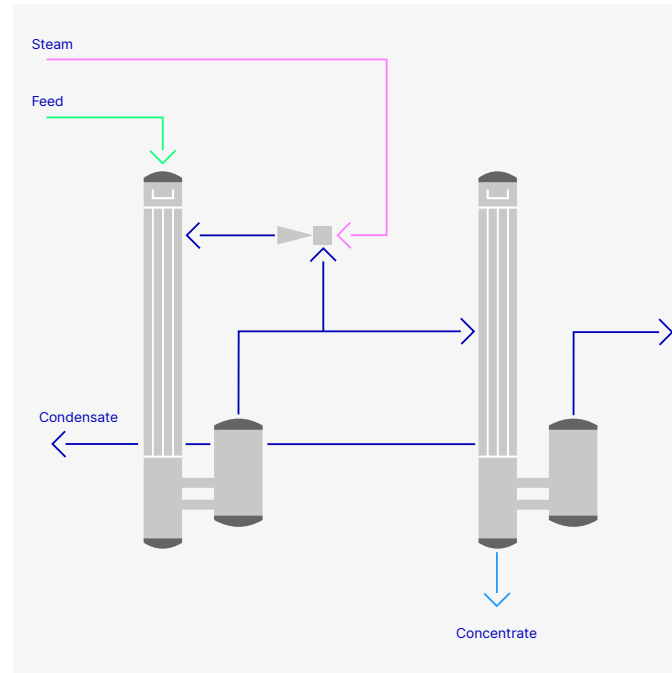


Fig. 2: Multi-effect evaporation plant, heated with direct steam and using TVR

During vapor recompression, vapor from the separator is recompressed to a higher pressure on the heating side of the tube bundle. For thermal vapor recompression (TVR), steam jet compressors are used. These compressors operate according to the steam jet pump principle and require a certain amount of steam, known as 'motive steam', for their operation. Approximately half of the vapor produced by the evaporation process can be reused for heating, while the other half flows to the next effect to drive the process there.

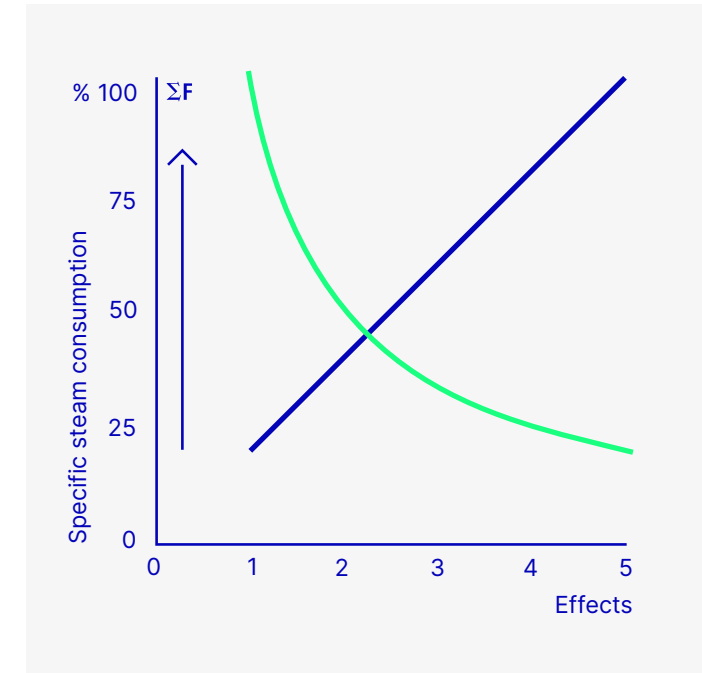


Fig. 3: Specific energy consumption vs No. of effects

This principle can be continued over several evaporation columns to further improve energy savings. The maximum permissible heating temperature of the first effect and the boiling temperature of the last effect result in a total temperature difference, which can be distributed to the individual evaporators. The more effects that are installed, the lower the energy requirement and the higher the investment.

Evaluating heat pump efficiency: COP's role

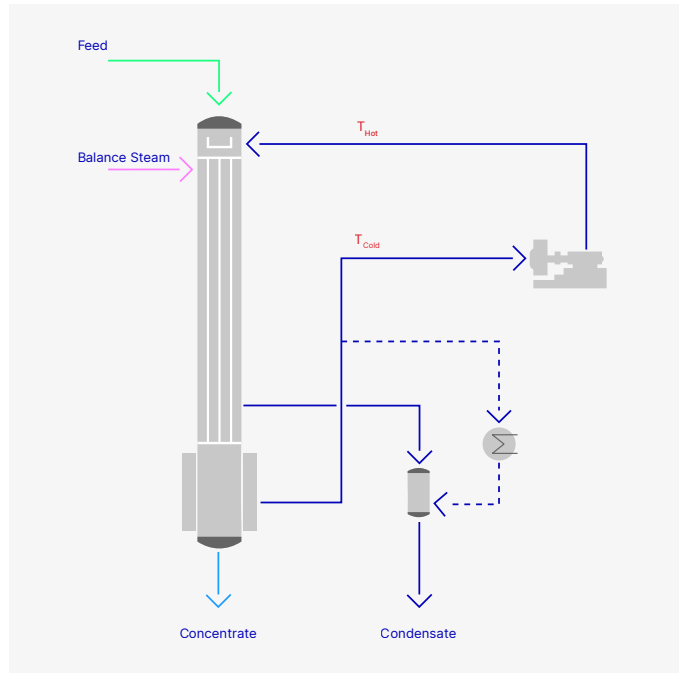


Fig. 1: 1-effect MVR evaporation plant

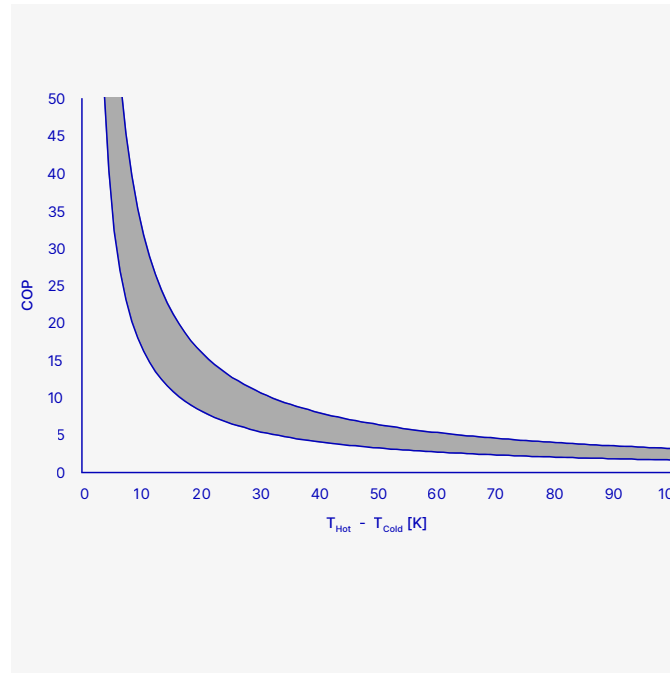


Fig. 2: COP of 1-effect MVR compared to thermal heating

Simplified calculation example:

- An evaporation plant is heated by 5 t/h of steam (at 1,2 bar(a)).
- The plant is revamped to MVR heating and the vapor temperature T_{Cold} is 65°C.
- The saturation temperature T_{Hot} downstream the MVR is 73°C.
- In this specific case, the MVR power consumption is 210 kW.

$$COP = \frac{Q_{\text{thermal}}}{Q_{\text{electric}}} = \frac{\dot{m} \cdot \Delta h_v}{E_{\text{el}}} = \frac{5.000 \text{ kg/h} \cdot 2.618 \text{ kJ/kg}}{210 \text{ kW} \cdot 3600 \text{ s/h}} = \frac{3.636 \text{ kW}_{\text{th}}}{210 \text{ kW}_{\text{el}}} = 17,3$$

The efficiency of a heat pump is indicated by its Coefficient of Performance (COP). The COP is determined by the ratio between the amount of used thermal energy and the electrical energy consumption of the compressor. The COP is a suitable characteristic value to assess the energy-saving potential of an evaporation plant with mechanical vapor recompression compared to a thermally heated evaporation plant (Figure 2).

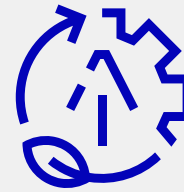
What does COP stand for?

A high COP value indicates high efficiency. Revamps from thermal to MVR heating with COP values of approximately ≥ 5 are profitable, depending on the energy costs and the expected amortization period, while MVR technology for new systems could be profitable at lower COP values.



PERFORMANCE PARTNERSHIP

Empower your business with a partnership designed to optimize your performance. Together with you, we create services that matter: We focus on your specific goals and help you increase **Availability, Productivity and Sustainability** – enabled by digitalization.



AVAILABILITY PRODUCTIVITY SUSTAINABILITY

Enabled by digitalization.



Enhancing Availability

Proactively minimize down-time with maintenance strategies and innovative technologies that ensure smooth, uninterrupted operations.



Boosting Productivity

Optimize efficiency with process improvements, staff training, and actionable, data-driven insights to maximize your production potential.



Driving Sustainability

Reduce environmental impact, improve resource-efficiency, and extend machine lifespans with tailored solutions and expert support.

Enabled by digitalization

- **Optimize and automate** your processes
- **Solve problems early** with predictive analytics
- **Identify untapped opportunities** through actionable insights
- **Make data-based decisions** – anytime, anywhere

Let's talk to unlock
your full potential



[GEA.com/service](https://www.gea.com/service)

AT A GLANCE.

Performance

- GEA Wiegand offers tailor-made wastewater treatment plants designed to meet specific requirements.
- The systems combine several process steps to achieve optimal results for water quality and recovery of valuable substances.
- Key features include maximum concentration of wastewater, minimal use of chemical substances, and complete separation of solid matters.
- The systems ensure low residual quantities, low disposal costs, and recycling of condensate as process water.

Digital

- GEA offers a range of digital products designed to enhance the efficiency and sustainability of thermal separation processes.
- GEA ProcessTwin creates a virtual replica of physical processes for real-time monitoring and simulation. It helps in predicting outcomes, improving efficiency, and reducing downtime.
- Automation of thermal separation plants at GEA involves using advanced solutions like stepsequence controlled processes and data-collecting sensors to enhance performance, ensure maximum uptime, and enable predictive calculations.



Proven technology – many applications.

Evaporation plants are required whenever in a process water or any other solvent has to be removed, concentration has to be increased, or volume reduced. GEA designs plant solutions using different evaporator types, plant configurations and heating options. Each evaporator type offers its own benefits, and the most suitable type is selected with consideration of the main process parameters: scaling tendency and accessibility for maintenance. Thermal separation processes are energy-intensive. In the course of its development, the aim to efficiently use this energy and reduce costs, finally by the use of mechanical vapor recompression systems.

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