DISTILLATION TECHNOLOGY

Applications, types, efficiency

GEA Engineering for a better world.

Contents

Research and development

Due to ongoing research and development work spanning many decades, and the experience of several hundreds installed references, GEA continues to provide the broadest technical expertise and the respected ability to offer the best solution for your application.

GEA operates multiple Research and Development Centers with advanced laboratory and pilot plants for in-depth analysis and testing in evaporation, crystallization, and distillation.

These centers determine crucial physical characteristics, such as boiling point elevation, viscosity, solubility, and maximum achievable concentration. Advanced computer programs capture data and model plant operating behavior.

What can GEA R&D offer you?

- From analytical & bench scale testing to pilot testing
- Tailor-made design relying on experience in combination with experimental data
- Development of new processes with qualitative and quantitative support
- In house or on-site support with pilot testing
- Standard lab data (physical properties) and complex Analytics (e.g. HPLC, GC, AAS)

Analytical inhouse capabilities are critical to understanding project chemistry and its impact on process design. The analysis of customer samples is often the basis of evaluation and proposing a customized solution.

DISTILLATION – UNLIMITED APPLICATIONS

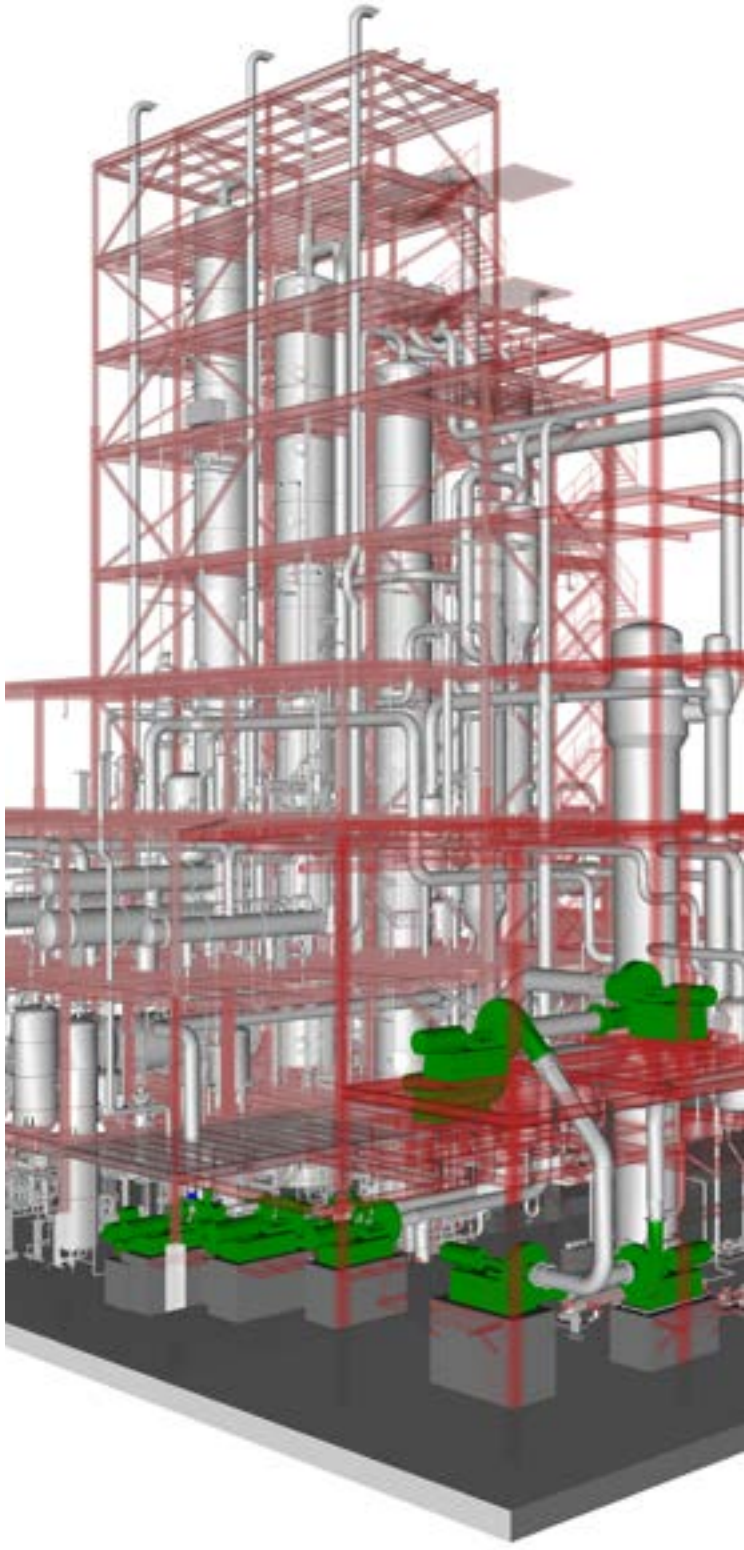
Chemical Industry
- Alcohols
- Esters
- Ethers
- Ketones
- Alkanes/Aliphatics
- Aromatics
- Chlorinated Solvents, Bio-Solvents or other Solvents

Biotech & Renewables
- Alcohol/Solvent-Dehydration with Molecular Sieves or Entrainers
- Glycerol/Methanol separation for Biodiesel
- Recycle of NMP/others in battery production
- HTF-Recovery for Solar Power Plants
- Bioethanol and advanced Biofuels

Pharma & Health Care
- Ethanol cleaning in Blood Plasma Fractionation
- NMP/DMAc/GBL Recycle at Membrane-Producers

Food & Beverage
- IPA-recovery in Pectin, Xanthan Production
- Drinking Alcohol & Liquor Production

MECHANICAL VAPOR RECOMPRESSION



Mechanical vapor recompression (MVR) reduces the energy costs and the CO_2 footprint and, consequently the environmental load.

Thermal separation processes, such as evaporation and distillation, are energy intensive. In the course of their development, the aim of efficiently using this energy and of reducing 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 distillation plants, the energy content of the vapor stream produced is lost to a large extent or is 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 reboiler of the column. Instead of live steam, electric energy is used indirectly to heat the plant.

Processes designed to save energy

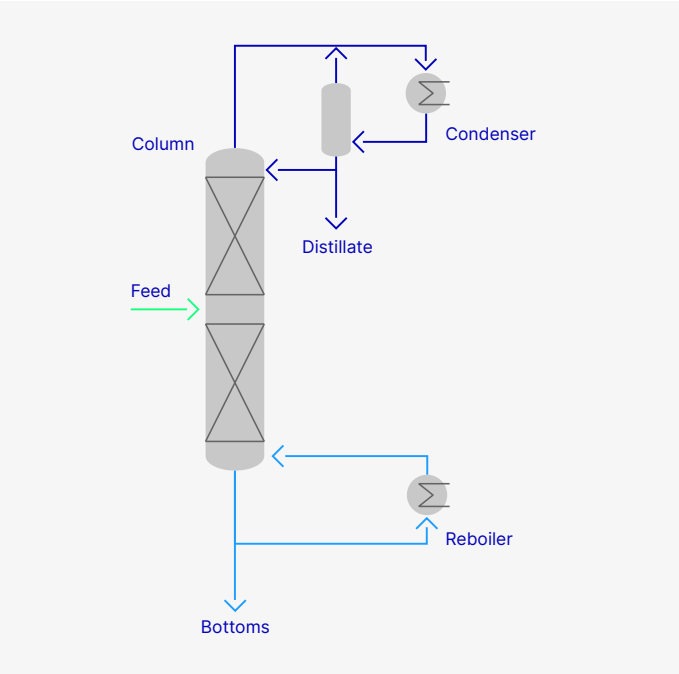


Fig. 1: 1-effect distillation plant

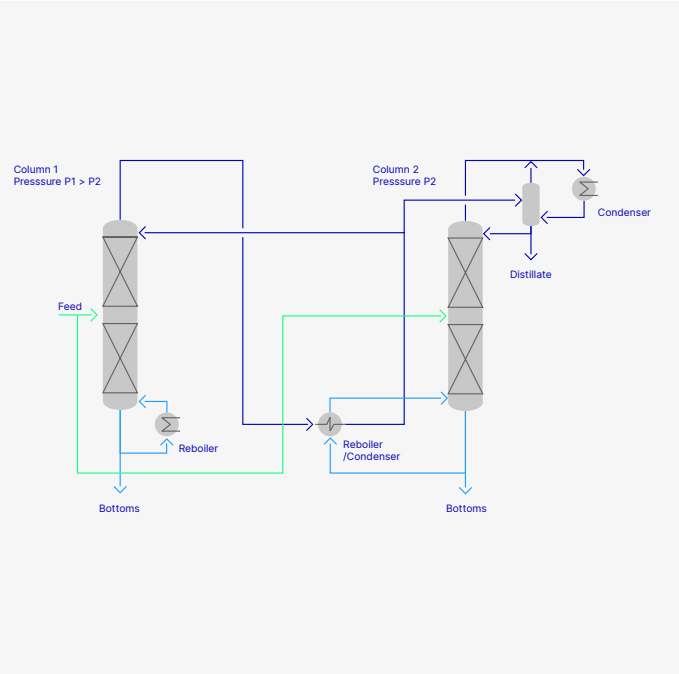


Fig. 2: 2-effect distillation plant

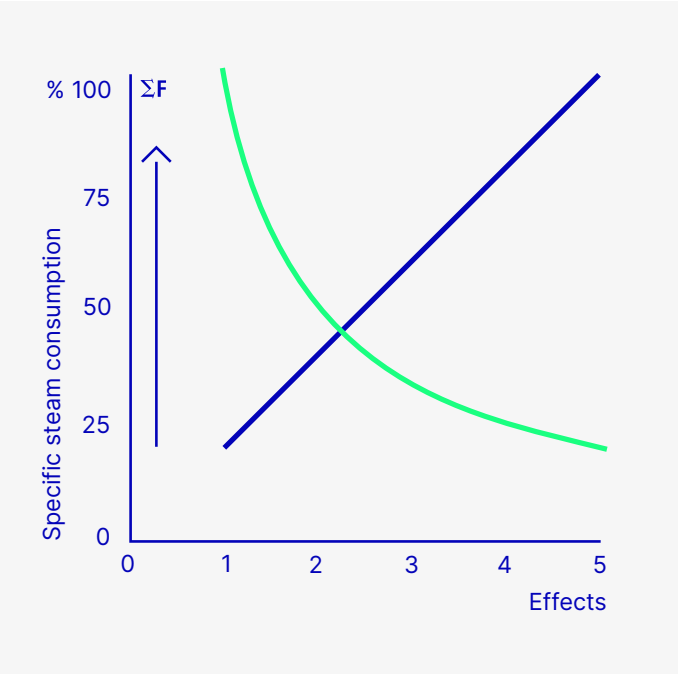


Fig. 3: Specific energy consumption vs No. of effects

Processes designed to save energy

During the distillation process, a vapor flow from the sump to the head of the column is required. In industrial-scale applications, these vapors are generated either via direct steam injection to the column or indirectly via a reboiler that is used as a heat exchanger for generating stripping vapor. Thermal energy is used to heat the liquid and finally to evaporate the low boilers.

Due to the evaporation/stripping of the low boilers, the bottom product is depleted in terms of low boilers, while the low boilers are concentrated in the head vapor. The head vapors contain approximately the same amount of energy as the steam which is heating the reboiler, however, at a lower pressure and temperature level. The vapors are condensed in a condenser and the distillate is partly used as reflux. By using the head vapors of the column as a heating medium for a downstream arranged reboiler, the required thermal energy is almost halved.

This principle can be continued over several distillation columns to further improve the energy saving. The max. permissible heating temperature of the first reboiler and the bottom temperature of the last column result in a total temperature difference which can be distributed to the individual reboilers. The more effects are installed, the lower the energy requirement and the higher the investment.

COP of MVR distillation plants

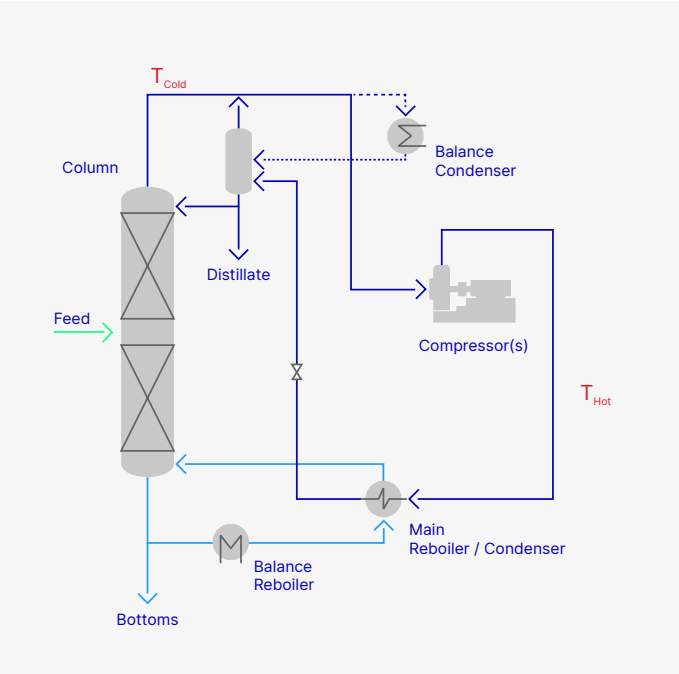


Fig. 1: 1-effect MVR distillation plant

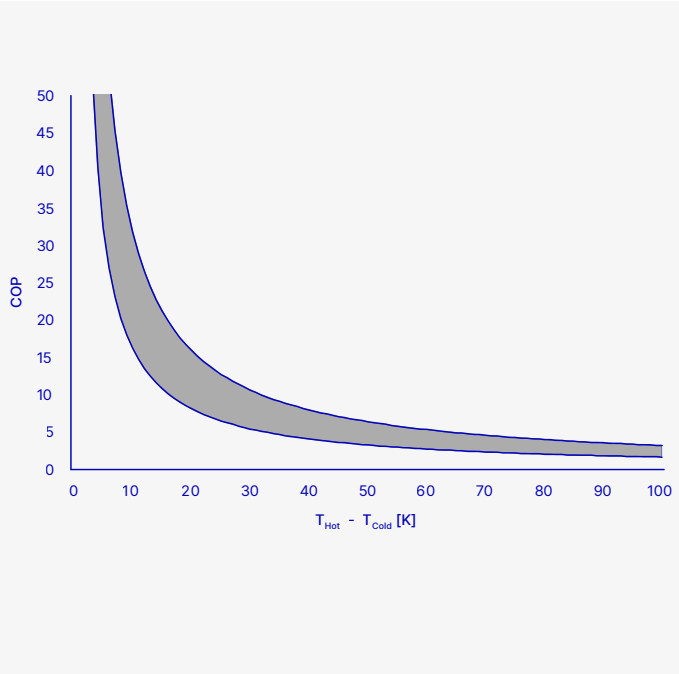


Fig. 2: COP of 1-effect MVR-heating within grey system efficiency range versus temperature difference

Simplified calculation example:

- A reboiler of a distillation plant is heated by 10 t/h of steam (at 2 bar(a)).
- The plant is revamped to MVR heating and the head vapor temperature T_{Cold} is 80°C.
- The saturation temperature T_{Hot} downstream the MVR is 104°C.
- In this specific case, the MVR power consumption is 600 kW

$$COP = \frac{Q_{thermal}}{Q_{electric}} = \frac{\dot{m} \cdot \Delta h_V}{E_{el}} = \frac{10.000\ kg/h \cdot 2.202\ kJ/kg}{600\ kW \cdot 3600\ s/h} = \frac{6.117\ kW_{th}}{600 kW_{el}} = 10,2$$

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 useful thermal energy and the electrical energy consumption of the compressor.

The COP is a suitable characteristic value to assess the energy-saving potential of a distillation plant with mechanical vapor recompression in comparison to a thermally heated distillation plant (Figure 2).

What does COP stand for?

A high COP value expresses for high efficiency.
Revamps from thermal to MVR heating with COP values of approx.≥ 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.

Columns & Internals

Columns form the core of any distillation plant. They are adapted to each application by the design and selection of different column internals. Computer modelling and pilot testing forms the basis of reliable designs.

Fig 1: Example sieve tray as column internal

Fig 2: Example high performance structured packing

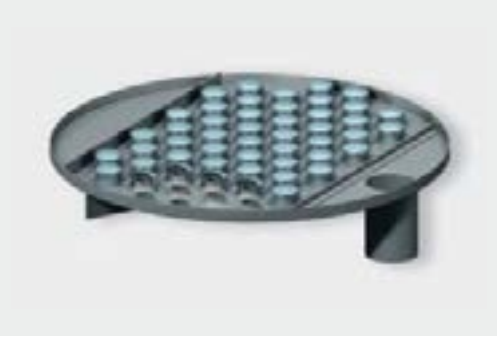


Fig 3: Example bubble cap tray for best turndown

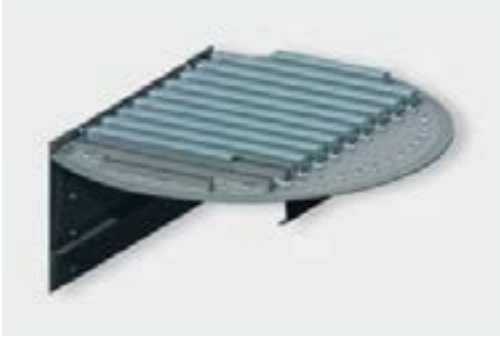
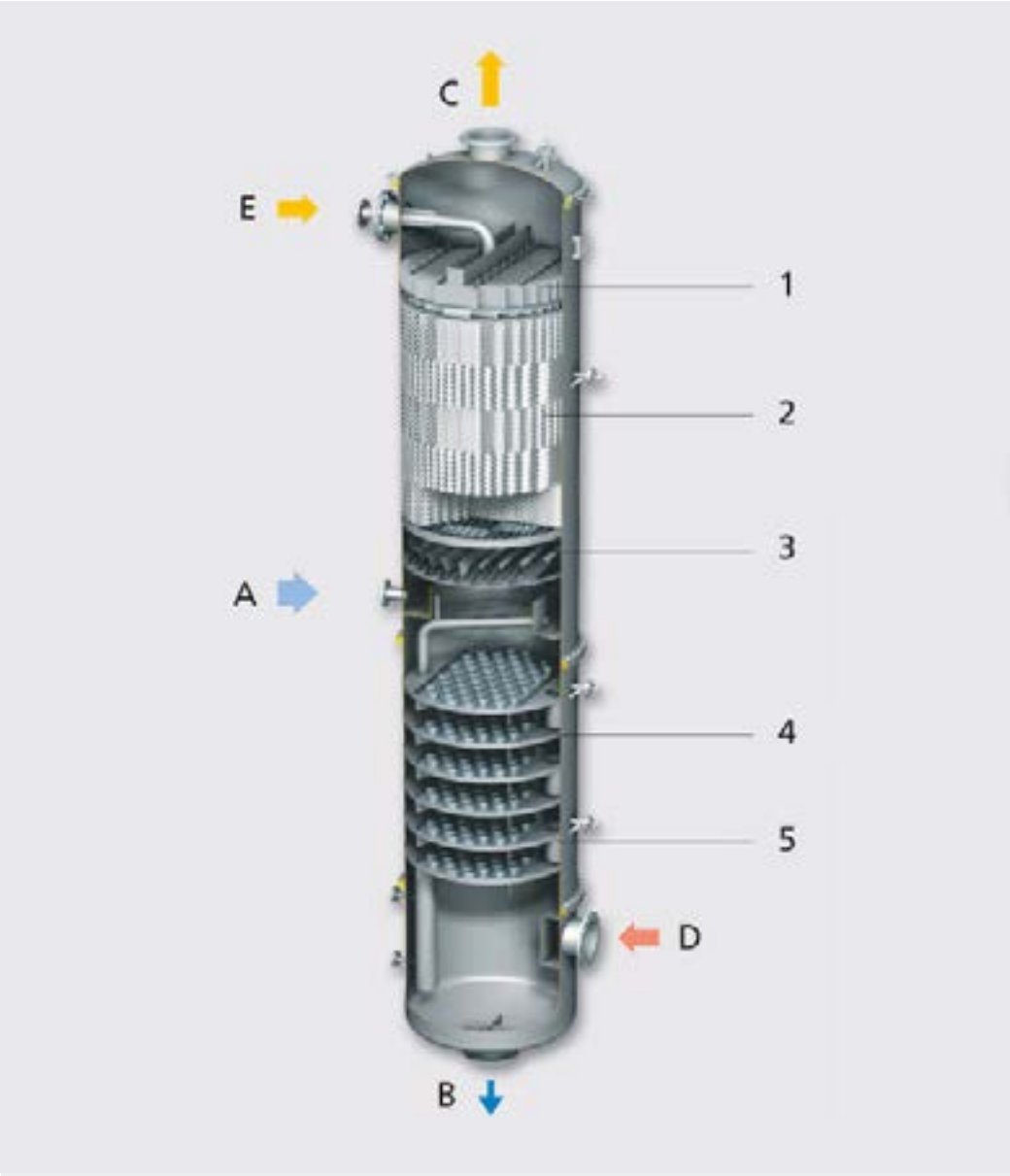


Fig 4: Example tunnel trays for special applications



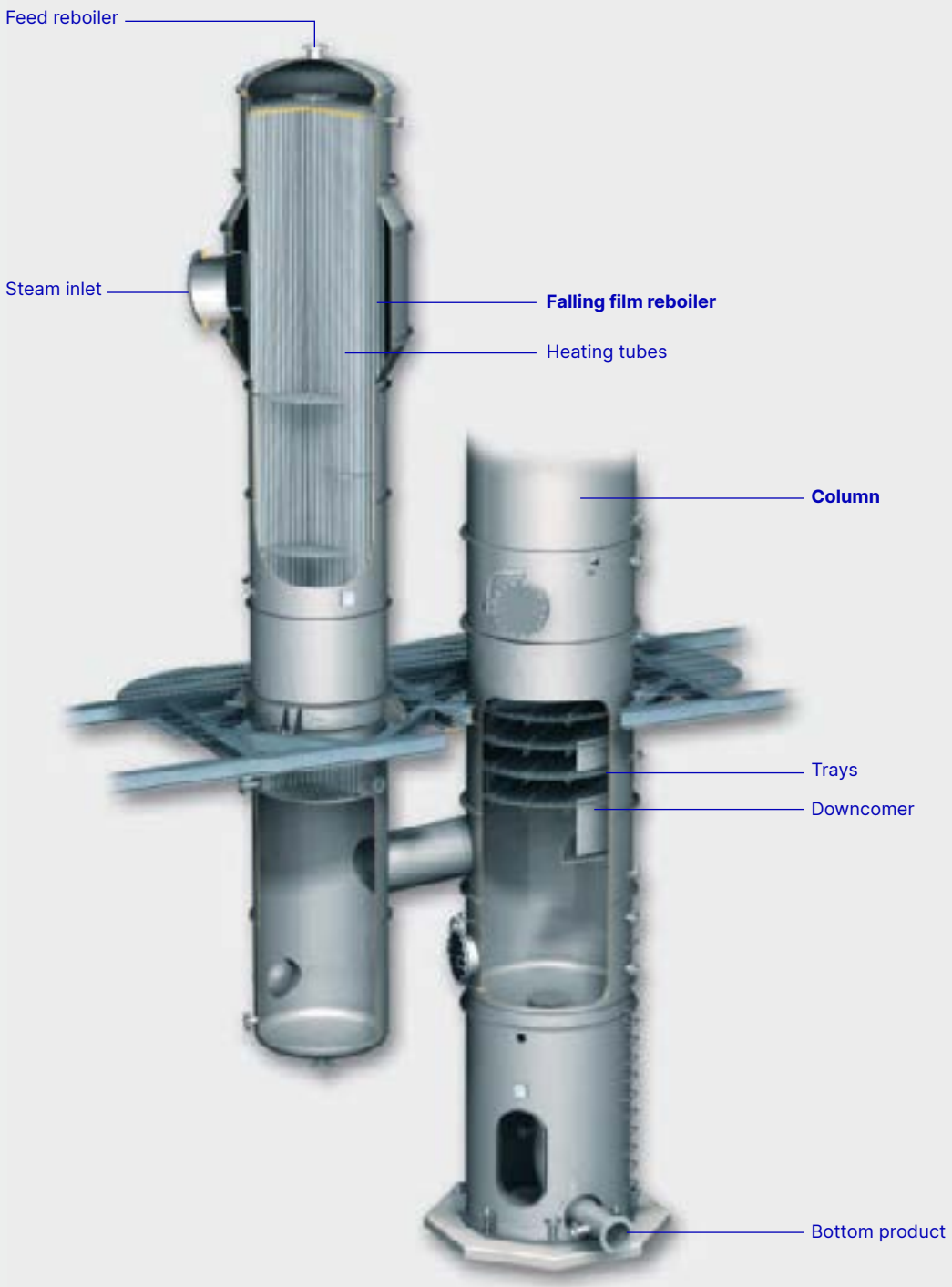
1 = Distributor, 2 = Packing, 3 = Liquid collector, 4= Trays, 5= Downcomer, A = Feed, B = Bottom product, C = Overhead product, D= Steam reboiler inlet, E = Reflux

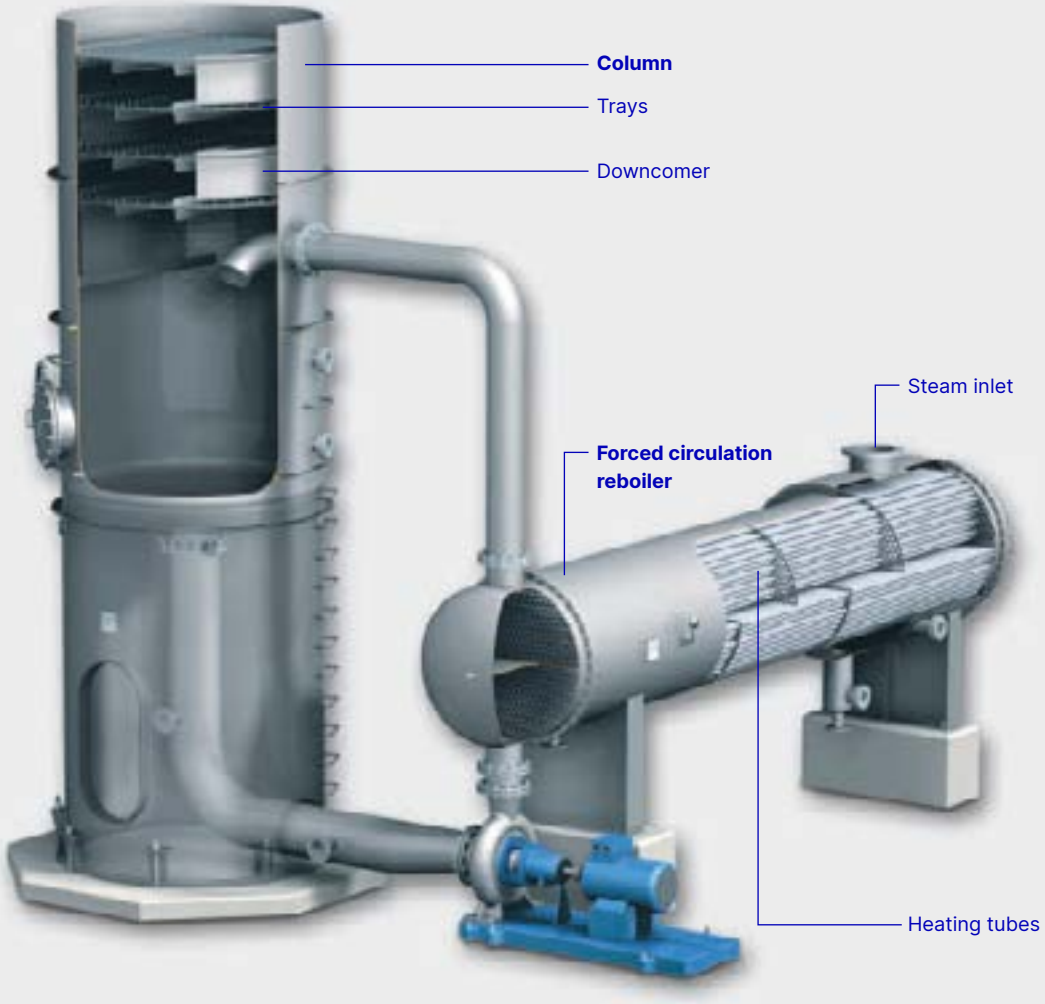
Reboiler

GEA uses different types of reboilers for the energy input to the distillation columns. The choice of the suitable type depends on surrounding process and product parameters.

The **falling film evaporator** as reboiler supports an easy adjustment and rapid start-up and shut-down of the column due to its limited liquid holding capacity. It is also suited to operation with very small temperature differences.

Falling film reboilers are therefore used for temperature-sensitive products and are particularly suited to multiple-effect distillation processes for energy saving.





Reboiler

Forced circulation reboilers
are used for reboiler duties where viscous and/or heavily contaminated media are to be expected in the bottom product.

High liquid velocities in the tubes and the resulting shearing forces ensure that this type of heat exchanger is operated within its optimum performance range, while keeping fouling to a minimum. Pump selection influences performance and efficiency.

Forced circulation reboilers can be designed for either horizontal or vertical installation.

Batch distillation plants

Batch operated units allow the distillation and rectification of diverse products or multiple component mixtures in one unit. It´s the multi-tasking-master in distillation applications.

Batch distillation is very flexible, but is typically used for small and medium-sized capacities. For larger units, a continuous distillation pant is usually more energy efficient and economical.

Batch distillations are frequent in the pharmaceutical industry for small scale solvent recovery applications, for the purification of high valuable oils or also in wastewater treatment units of small capacities.

Two operational modes are possible for the batch process:

1. In the batch distillation with a fixed reflux ratio, the compounds are separated according to a defined product specific time schedule. This is based on the components´ boiling ranges , that lead to a fractionation of the different components: beginning with the light boilers and ending with the heavies. The classical application is the fractionation of multi-component–mixtures.

2. The batch distillation with a varying reflux ratio allows the distillation at a constant distillate concentration; it is applied where a distillate with constant physical behaviour needs to be obtained.

Multiple-effect distillation plants

GEA Distillation is recognized for the high thermodynamic efficiencies, high product yield and high distillate purities achieved.

The core of such distillation plants is a multiple-effect pressure/vacuum distillation/rectification system. The design is largely determined by the characteristic properties of the feed and the specific requirements of the final product.

Multiple-effect distillation permits the repeated use of the energy supplied to a system. Energy consumption is effectively reduced by a factor about equal to the number of effects. Since a temperature difference is required for heat transfer within the reboiler, there are practical limitations to the number of effects that can be used. Maximum and minimum temperatures are, as a rule, determined by the product, or the heating steam pressure and the cooling water temperature.

Skid mounted distillation plants

The fabrication of compact skid mounted units for smaller product quantities has several advantages for our client:

- Reduction of engineering demand on client's side
- Reduction of interfaces
- High safety of overall project costs
- Minimum installation time and independence of running processes during assembly
- Possibility of workshop testing
- Minimized production loss due to short installation period

GEA´s skid mounted units are limited to/by the transporting dimensions. If necessary the required units are split in subunits and are interconnected on site.

Process automation, plant performance and service

The major goal of any production plant is to achieve the desired product at constant quality by continuous productivity

All parameters which might influence the evaporation plant or alter the mass and heat balances need to be monitored and controlled. In accordance with the technical and customer's requirements, GEA evaporation plants can be equipped with the relevant measuring and control systems up to fully-automatic process control systems. We use Siemens SIMATIC PCS7, GEA Codex® or any other suitable software requested by the customer. Instrument and system specifications are selected in cooperation with our customers to ensure the best hardware service during the lifetime of the plant.

Being a partner to our customers is our mission. GEA provides support throughout the entire life cycle of a delivered plant and equipment to ensure business success. To guarantee optimal performance and operational excellence, we provide a wide range of services to maintain and improve your plant and equipment.

Beginning of life cycle service

Getting you started with seamless support for instant productivity and performance. Installation, commissioning and staff training are carried out by our assembly supervisors, project engineers and process control experts. On request we create an enhanced Digital Twin (3D model plus dynamic process simulations) of your plant with variable automation levels.

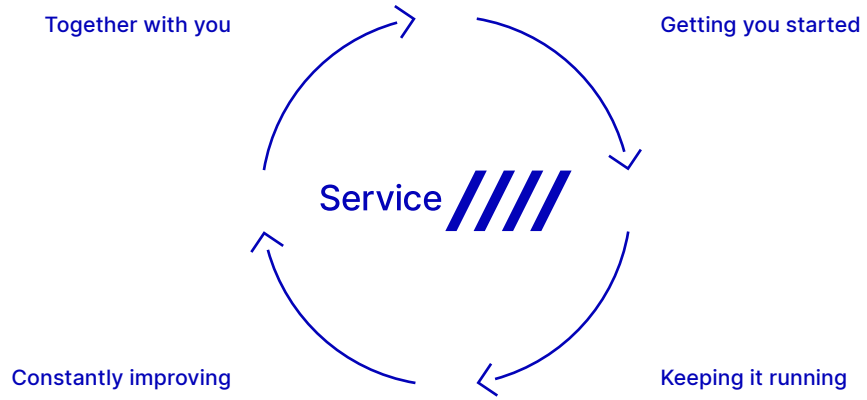
This has significant benefits:

- The process control can be programmed and tested before commissioning of the plant with the Advanced Factory Acceptance Test (FAT) using the dynamic process model.
- Virtual commissioning shortens the commissioning time and identifies errors in advance.
- Operator training at the virtual plant help familiarize the operators with the plant before its commissioning.

FOR YOUR CONTINUED SUCCESS.

GEA Service offers dedicated teams of service experts. Our focus is to help our customers build, maintain, and improve their performance, market presence and competitive edge for the entire life cycle of their plants and equipment.

Partnering with GEA gives you the benefit of our world-renowned, customer-tailored service and recommended spares upgrade, modernization and optimization services. With our support you can be certain that every piece of GEA equipment and technology will operate optimally from day one, and for its complete lifespan, to give you maximum return on your investment.



Getting you started –
Seamless support for instant productivity and performance

Keeping it running –
The cost-efficient way of ensuring safety and reliability

Constantly improving –
Sharing our knowledge to safeguard your investment

Together with you –
Enduring commitment to you and your business

Engineering for a better world.

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