Making our world more productive

Coil-wound heat exchangers

Individually designed to customer needs

Built to last.

+1,000

coil-wound heat exchangers manufactured.

In May 1895, Carl von Linde succeeded in liquefying air on an industrial scale using coil-wound heat exchangers (CWHE). This marked the start of Linde's long and proven track record in delivering CWHE-enabled cryogenic applications. Improvements to aluminium welding technology in the late 1950s enabled engineers to switch from expensive and heavy copper to cheaper and lighter all-aluminium designs.

Linde has since manufactured more than one thousand CWHEs for various applications in materials such as stainless steel, special steel alloys, carbon steel, copper and aluminium. These heat exchangers enjoy an excellent reputation for their quality and technical reliability. In fact, many of them are still in operation.

Winning combination.

Each of our CWHEs has been individually designed by our engineering experts to meet customer-specific thermal and hydraulic performance requirements while keeping investment and operating costs to a minimum. These optimised designs combine our proven fabrication technologies with the highest quality standards to create cutting-edge heat transfer solutions for various process applications. In addition, our process experts can also perform lifetime estimations of the equipment, investigating the cyclic loads of CWHEs taking all relevant process conditions into account.

Experience gained through operational feedback

As many of our CWHEs are operated by Linde Group entities and third-party customers around the world, Linde Engineering benefits from a steady stream of operational feedback. Working closely with local operating teams, our engineers then channel these insights directly into our design process to continuously improve our equipment.

Customer focus

Our customer-orientated teams include experts in process and mechanical design, as well as experienced service staff. These specialists travel around the globe to support our clients during start-up or regular operations. They are also on hand to help with performance-boosting initiatives.

What is a coil-wound heat exchanger?

Supporting a temperature range between

–269°C

and

+650°C

Within this type of heat exchanger, several layers of tubes are helically wound around a large centre tube, known as a mandrel. This tube bundle can be designed in such a way that it can contain more than one tube fraction to accommodate different process media. Both ends of the tubes are welded to tube sheets or ring pipes. A pressure vessel, which is manufactured in parallel to the tube bundle, encloses the entire bundle.

Robust design

Due to the special "spring-like" design, our CWHEs are extremely robust. Supporting a temperature range between –269°C and +650°C, they can handle much larger temperature and pressure differences than other heat exchanger types. The tube bundle simply shrinks or expands during start-up or shut-down, for instance, to accommodate these large changes in temperature. In addition, our proprietary support system effectively eliminates the potential for bundle sagging.

Our CWHEs are designed according to customer needs.

Principle assembly of a coil-wound heat exchanger for LNG plants

What are our CWHEs used for?

The robust design and wide temperature and pressure envelope of our CWHEs make them ideal for a broad spectrum of cryogenic and high-temperature applications, especially where fast temperature changes and cyclical temperature and pressure loads are specified. The fact that they can be made in a variety of materials makes them suited to service in almost every chemical environment.

Our CWHEs are used mainly for clean fluids in the following plants and applications:

- → LNG and natural gas processing plants
- → Acid removal in RECTISOL® plants
- → Solar thermal power plants
- → Methanol synthesis
- → Shift conversions
- → Hydrogenation
- → Methanation
- → Vaporisation with water bath

Typical dimensions of a large CWHE:

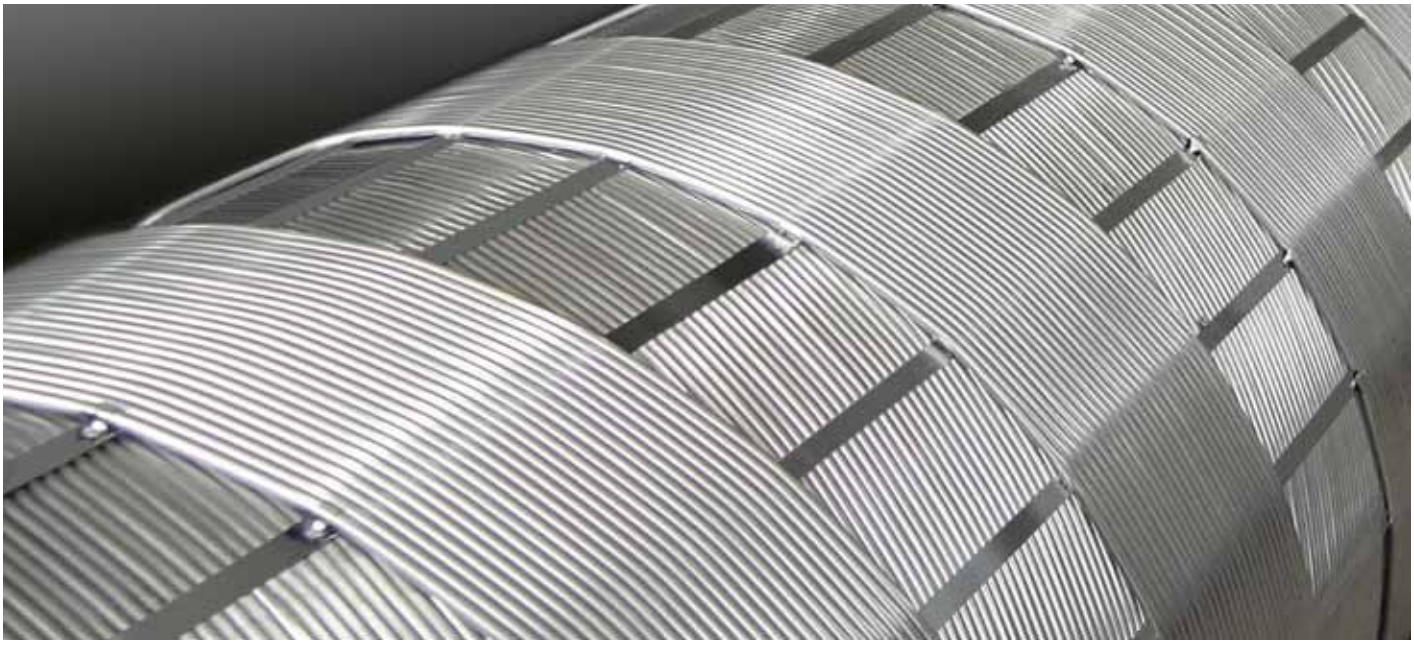
Length: 60 m
Diameter: 5 m
Active area: 35,000 m^2

Design temperature:

–269°C to +650°C

Design pressure:

- up to 300 bar (g) shell side
- up to 1400 bar (g) tube side



Coil-wound heat exchanger bundle.

Perfect fit.

We are in the unique position of being able to combine more than 100 years' experience with the synergised operational and engineering expertise of our Gases and Engineering Divisions. This rich knowledge base ensures that each CWHE is the perfect fit for individual application challenges – serving customers both within and beyond The Linde Group.

We match the materials, tube dimensions and bundle geometries to the specific requirements of each project. Customers can also rely on our experts for process consulting to optimise the overall system design, increase plant capacity or reduce operating costs further down the line.

Wide choice of materials and configurations

There are virtually no limits to the choice of materials for our CWHEs. In LNG applications, for instance, aluminium CWHEs are often the perfect choice due to their cryogenic suitability and lightweight design. For harsh environments such as offshore settings and high-temperature applications, stainless steel may be the more robust option.

For extreme high-temperature operations such as molten salt applications, special carbon steel alloys are available. Of course, we also offer conventional carbon steel for less extreme environments. Our experts design and build equipment to match individual customer specifications, always looking for the best performance and price ratio.

Similarly, we accommodate a wide range of process configurations. We support just about every service, including co-current and counter-current stream layouts, two-stream and multi-stream configurations, falling film evaporation and upwards condensation, as well as once-through steam generation and reboiler operations. And if you have special requirements for dynamic load changes – for example fast daily start-ups at solar power plants – our engineers will come up with a proposal that gives you the operational flexibility you need.

>100
years' experience.

CWHEs are part of many process plants.

CWHEs for LNG plants.

Characteristics

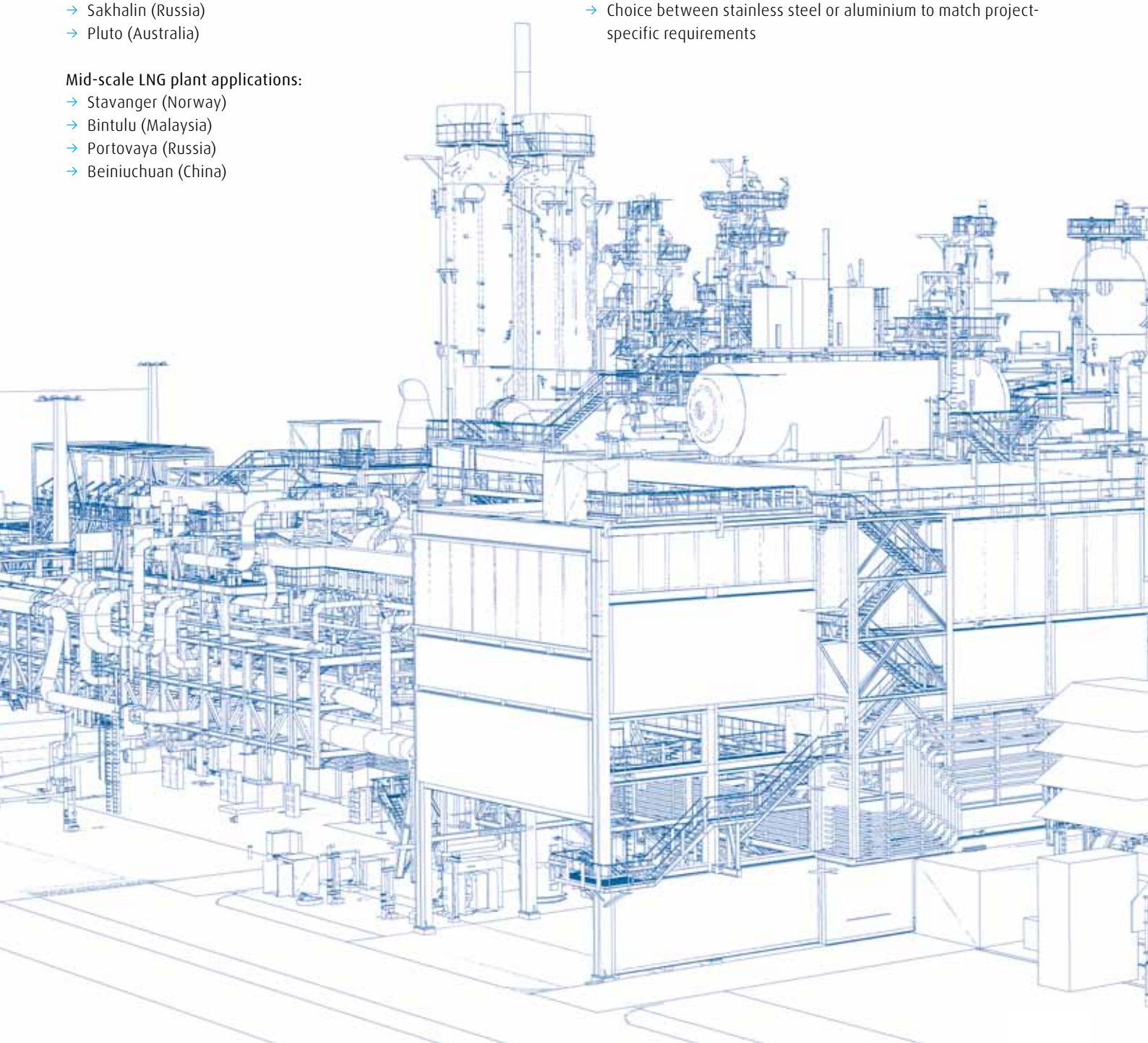
Our CWHEs act as the main cryogenic heat exchanger (MCHE) or precooler in numerous LNG plants worldwide. Building on decades of LNG experience and continuous development, our CWHEs treat natural gas with the utmost efficiency and outstanding reliability. They are used in different liquefaction processes and cover a wide load spectrum such as:

World-scale LNG plant applications:
- Hammerfest Snøhvit (Norway)
- Brunei (Brunei)
- North West Shelf (Australia)
- Sakhalin (Russia)
- Pluto (Australia)

Mid-scale LNG plant applications:
- Stavanger (Norway)
- Bintulu (Malaysia)
- Portovaya (Russia)
- Beiniuchuan (China)

Benefits

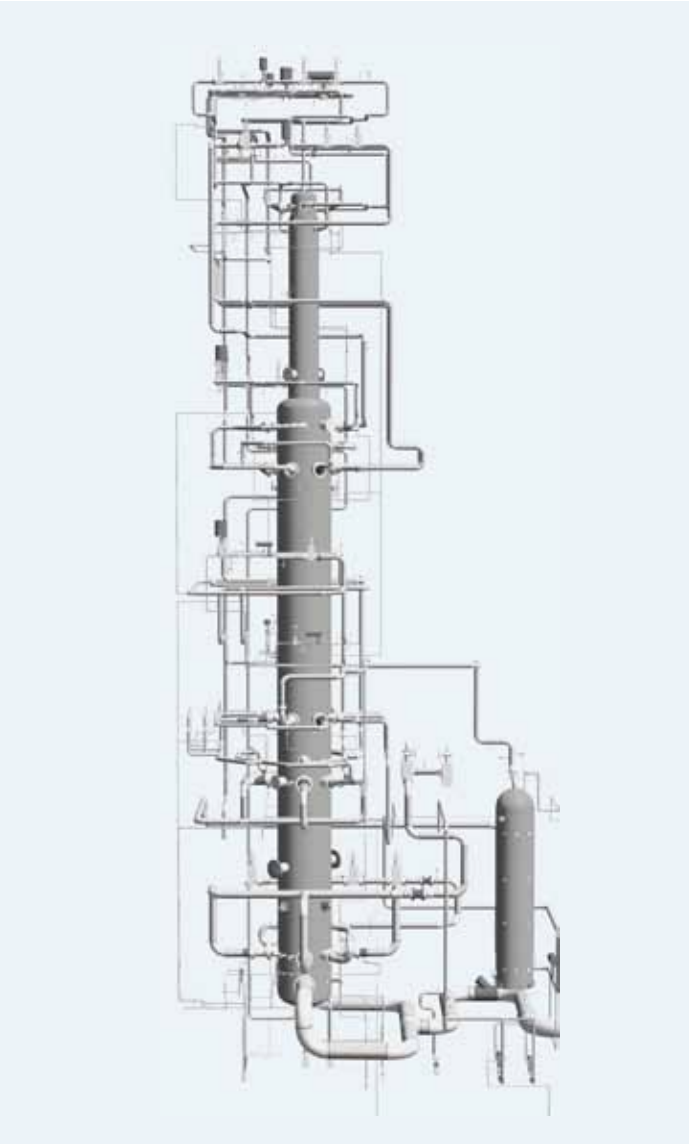
- High efficiency due to flow channel optimisation with computational fluid dynamics
- High reliability and robustness due to patented bundle fixation and winding process supported by finite element methods
- Sophisticated liquid distributor to cope with wide load ranges
- Patented adjustable tube side and distributor control to optimise heat transfer at different operation points in order to maximise efficiency or LNG output
- Elaborate quality checks of every single component before assembly, e.g. liquid distributor tests in our own testing facility to ensure perfect performance of every single distributor
- Choice between stainless steel or aluminium to match project-specific requirements



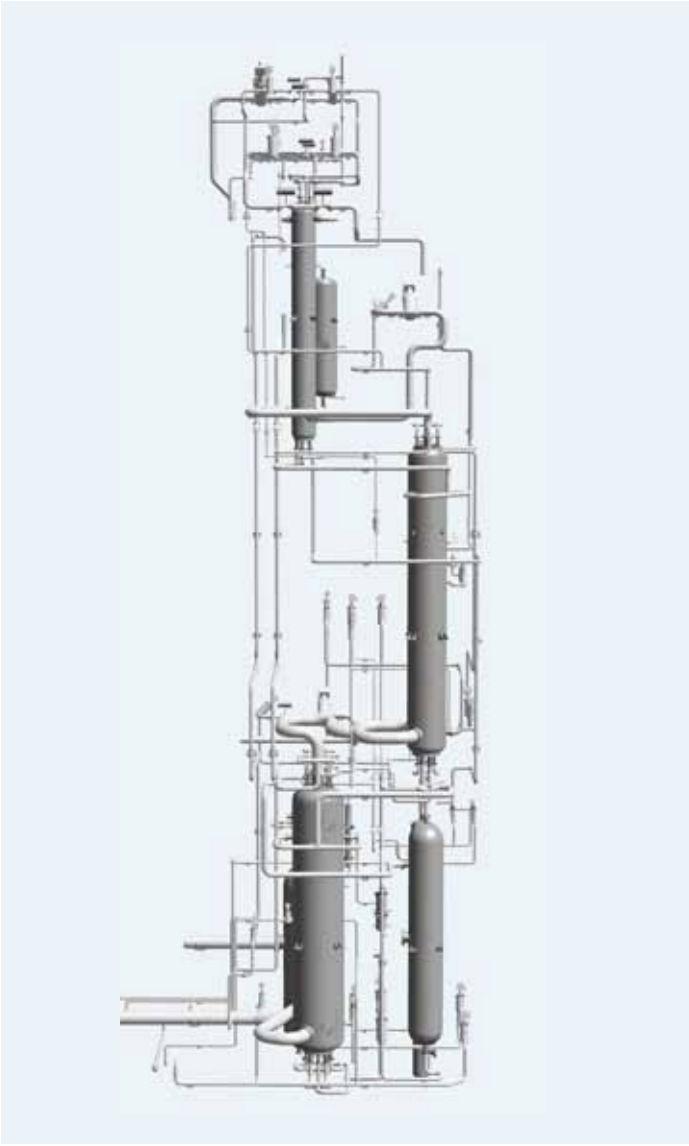
Packaging options for LNG applications.

We have the flexibility to design and build CWHEs to match project-specific requirements. Especially in LNG applications, two or three bundles in series are common. Here, customers can choose what is known as the “rocket” arrangement, where the bundles are placed on top of one another in one large pressure vessel with a height of 60 m or more, or a single vessel for each bundle.

The CWHE rocket design has the advantage of being “ready to run” when it leaves the plant, whereas single vessels have the advantage of easier transport and more installation freedom. Specific project requirements, country specifications or transport restrictions may influence the choice.



CWHE rocket design.



Single vessel design.

CWHEs for RECTISOL® wash units.

Characteristics

Our CWHEs are a reliable solution for all RECTISOL® processes, offering outstanding results due to their pure counter-current flow characteristic, robustness and ability to cover a large capacity range. Compared with shell and tube heat exchangers (STHEs) in series, which can also be used, CWHEs have a number of benefits.

Benefits

- Depending on the project, the capacity of one CWHE can equal six STHEs
- Reduced energy consumption and less need for insulation, steel structure, instrumentation and piping
- Reduced plot space of one CWHE versus six STHEs (see graphic below)
- Several streams can be cooled down or warmed up in one CWHE
- Vibration-free design
- Possibility of trouble-free shell side two-phase flow

Comparison of STHE vs. CWHE.

CWHEs as water bath vaporisers.

Characteristics

Our water bath vaporisers (WBVs) are a robust and reliable solution for the gasification of cryogenic fluids within a very large capacity range. A WBV unit consists of a water-filled vessel with a submerged coiled tube bundle. The water can be pumped (for a fast, responsive design) or flow in natural circulation (for a simple, cost-effective design). The liquefied gas that passes through the tubes is instantly heated by the water and thus vaporised up to product temperature and pressure.

WBVs are primarily installed in back-up systems at air separation plants that must be started in a matter of seconds/minutes to ensure continuous plant operations. However, they are also used in petrochemical and LNG plants, for instance to heat flare gas or boil-off gas.

Benefits

- Vaporisation of up to three product streams in one single heat exchanger
- Pressure build-up of cryogenic tanks can be incorporated in the same heat exchanger
- Increased safety due to water bath thermal buffer in the event of interruption to steam supply
- Optional usage of special tube inserts to reduce pressure and flow fluctuations and therefore improve operational stability and process safety
- Suitable solution to handle ice formation during normal operation due to flexible ring distributor
- Small footprint due to high energy density and vertical design

Operational
stability and process safety.

Typical dimensions of a large WBV:
Vessel diameter: up to 3.5 m
Vessel height: up to 11 m
Heating surface: up to 1,000 m^2

Pressure:
up to 400 bar (g) tube side

Temperature:
from –269°C to approx. +150°C

Nominal capacity:
up to 150,000 Nm^3/h

Bundle of a water bath vaporiser.

CWHEs in molten salt applications.

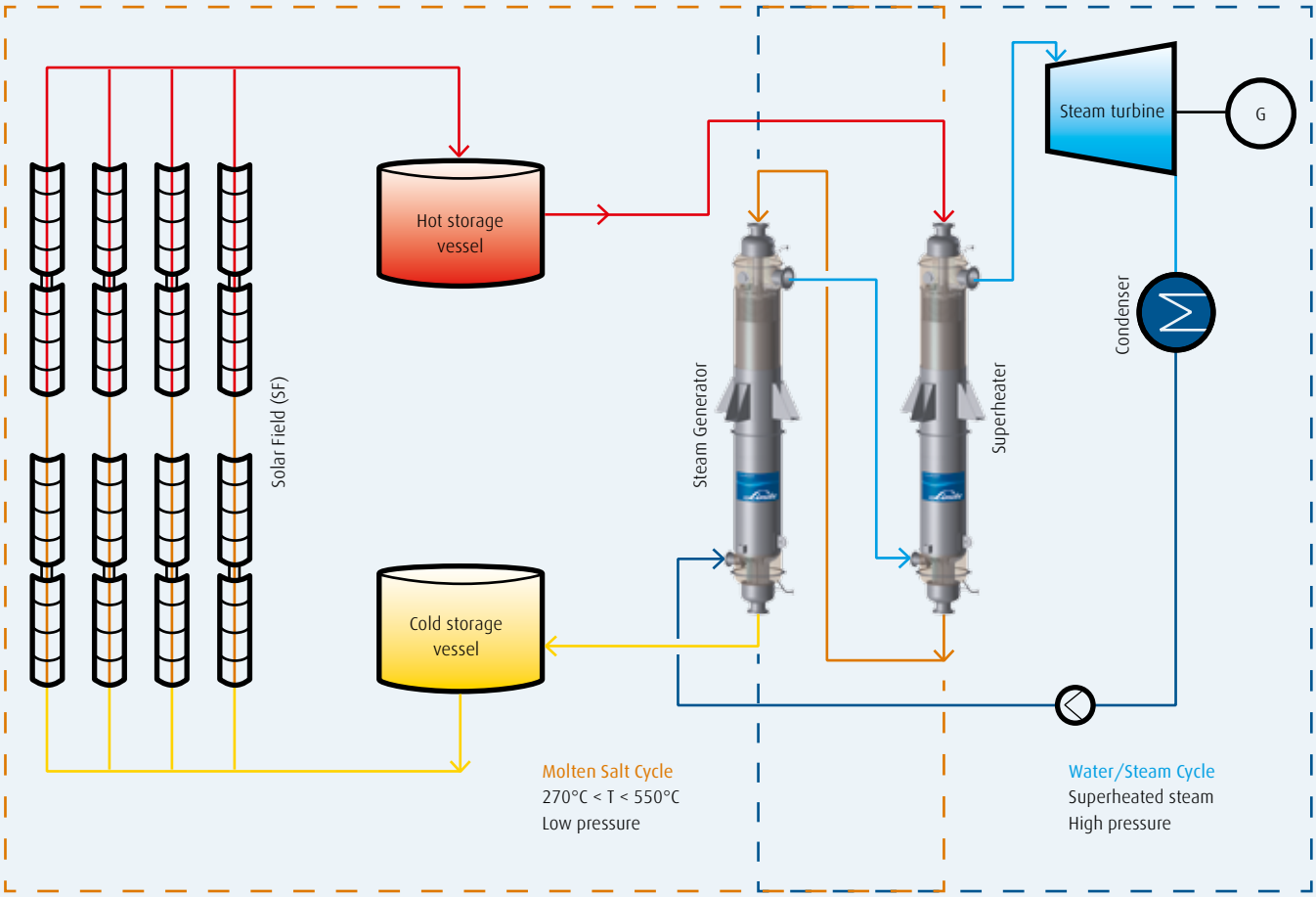
Characteristics

The molten salt heat exchanger is the core component in thermal energy storage (TES) plants. Here, the CWHE is typically operated consecutively in charge and discharge mode, with the result that it transfers excessive heat energy to the storage system on the one hand, and, on the other, discharges energy from the storage system back into the energy loop. The main characteristics of molten salt exchangers are high working temperatures, in some cases high pressure, wide load range variations during the day and quick start-ups. Our CWHEs are ideal for heat storage applications due to their high mechanical flexibility, allowing very fast temperature changes in the media (typical of solar power plants).

Benefits

- High mechanical flexibility due to ability to cope with high temperature differences and thermal stress during change of operation mode
- Combination of co-current and counter-current flow to improve the efficiency of the TES
- Self-draining geometry
- Reduced plot space and equipment count compared with straight-tube heat exchangers

Typical molten salt flow sheet



CWHEs as isothermal reactors.

Characteristics

Our isothermal reactors are fixed-bed reactors suitable for endothermic and exothermic catalyst reactions with indirect heat transfer. The main difference between these and other reactors with integrated heat exchangers is that the helically coiled tubes are immersed in the catalyst bed. They are characterised by a significantly higher heat transfer compared with tubular reactors with a catalyst inside the tubes, which results in a much smaller heating area. For example, the tube bundle surface area of our reactor is approximately 25%–45% smaller than that of a tubular reactor with the same performance for methanol synthesis processes.

Our isothermal reactors can be used for gas/gas, gas/liquid and liquid/liquid reactions, making them an excellent solution for various processes in the chemical industry. These include:

- Methanol synthesis
- Shift conversions
- Claus processes
- Hydrogenation
- Methanation
- CLINSULF® sulfur recovery

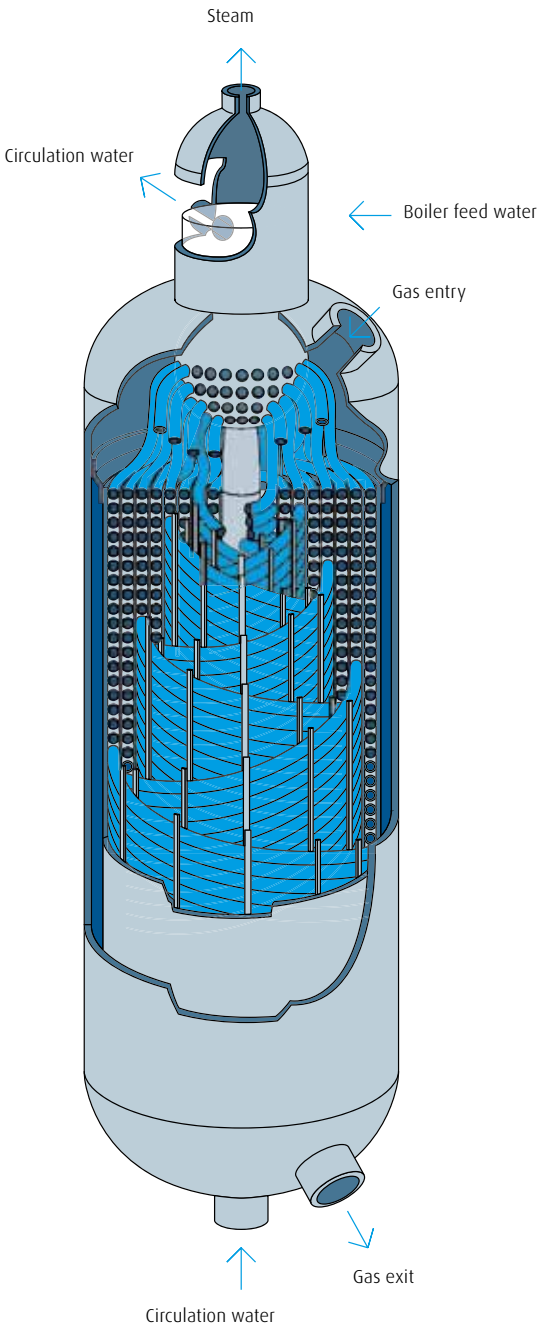
Benefits

- Highest catalyst volume per reactor volume for an isothermal reactor
- Comparatively low number of tubes, minimising the diameter and wall thickness of the hemispherical tube sheets
- Cost advantages through compact design
- Easy temperature control by adjusting the steam pressure
- Integrated steam drum with natural boiler water circulation
- Smooth behaviour during catalyst activation, normal operation, fast start-up and shut-down procedures and catalyst deactivation
- Proven design with numerous running references

Bundle surface area approx.

25%–45%

smaller than a tubular reactor for methanol synthesis.



Equipment design

- Lifetime estimations in the case of cyclic loads by means of Finite Element Analyses (FEA)
- Continuous improvement of CWHEs using our in-house design tool, including methods for heat transfer and pressure drops even in non-equilibrium boiling regimes and for falling film evaporation
- Close alignment with process simulation to optimise thermodynamic, hydraulic and mechanical designs and minimise both operating and capital expenditure

Manufacturing

- Finite Element Analyses (FEA) to address several manufacturing and winding issues
- All CWHEs have been manufactured at our site in Germany for the past 60 years
- CWHEs can be supplied in line with all major design codes

Logistics and installation

- Qualified and experienced erection engineers, fitters and welders
- Execution and/or supervision of all CWHE installation work on site
- Shipment to any location worldwide

Operational diagnosis

- Expert teams with the right qualifications, experience, certificates and tools
- Emergency team for analysis of unplanned shutdowns
- Inspections and, if necessary, fast-track repair service
- Support and operator training for the best operation of our CWHEs
- Optimisation of operations using 3D view of inner bundle temperature distribution captured by fibre optic temperature sensors

Optimisation and revamp studies

- Investigation of capacity increase potential at existing plants
- Re-designs to modernise operations
- Execution of modification site campaigns (e.g. with up to 115% of its name plate capacity)

Research and development

- Extensive in-house cryogenic testing facilities to explore new developments
- Validation of calculation methods with own pilot-scaled test plants (e.g. cryogenic test rig for LNG or qualification of tube inserts for performance and stability improvements to WBVs)
- Geometry optimisation using computational fluid dynamics (CFD) with cutting-edge two-phase flow modelling approach

Manufacturing site at Schalchen (Germany).

Manufacturing excellence

All coil-wound heat exchangers are manufactured at our Linde Engineering site in Schalchen, Germany. There we combine leading technologies from The Linde Group with our professional management skills to support our customers with top-quality products and value-added services such as field installation and advice on operation.

To find out how your process plant can benefit from our world-class technologies, global reach and outstanding support services, visit linde-engineering.com/plantcomponents or contact your local Linde Engineering sales office.

Read more:
linde-engineering.com/plantcomponents

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Your partner for the production and processing of gases

Delivering reliable process plants for maximum capital efficiency

Linde has been optimizing gas processing technologies for 140 years, successfully delivering more than 4,000 plant engineering projects around the globe. Favoring trusted, lasting business relationships, the company collaborates closely with customers to enhance plant lifecycle productivity and innovate process flows. The company's proven gas processing expertise plays an indispensable role in the success of customers across multiple industries – from natural gas and oil refining through petrochemicals and fertilizers to electronics and metal processing.

Operational excellence along the entire plant lifecycle

We work closely with our customers to gain an in-depth understanding of individual needs. Building on the unique synergies of Linde as an integrated plant operator and engineering company, Linde offers innovative process technologies and services to exceed our customers' reliability and profitability expectations. This commitment to innovation extends along the entire plant lifecycle. The LINDE PLANTSERV® service team supports customers every step of the way – from maintenance and repairs to full revamps. Leveraging the latest digital technologies to offer on-site and remote operational and support services, we consistently take asset performance to the next level.

Making the impossible possible

From the desert to the Arctic, from small- to world-scale, from standardized to customized designs, Linde's engineering specialists develop solutions that operate under all conditions. The company covers every step in the design, project management and construction of gas processing plants and components. Customers can always rely on Linde to deliver the plants, components and services that fit their needs best – anywhere in the world.

Discover how we can contribute to your success at www.linde-engineering.com

Get in touch with our component manufacturing team:
Phone +49 8621 85-6473, inquiry: www.linde-engineering.com/contact

Core competencies at a glance

Plant engineering
- → Air separation plants
- → LNG and natural gas processing plants
- → Petrochemical plants
- → Hydrogen and synthesis gas plants
- → Adsorption plants
- → Cryogenic plants
- → Carbon capture and utilization plants
- → Furnaces, fired heaters, incinerators

Component manufacturing
- → Coldboxes and modules
- → Coil-wound heat exchangers
- → Plate-fin heat exchangers
- → Cryogenic columns
- → Cryogenic storage tanks
- → Liquefied helium tanks and containers
- → Air-heated vaporizers
- → Water bath vaporizers
- → Spiral-welded aluminum pipes

Services
- → Revamps and plant modifications
- → Plant relocations
- → Spare parts
- → Operational support, troubleshooting and immediate repairs
- → Long-term service contracts
- → Expert reviews for plants, operations and spare part inventory
- → Operator training

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