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MEGGITT
smart engineering for
extreme environments

Heatric

Compact
Heat
Exchange

MEGGITT
smart engineering for
extreme environments

The PCHE Opportunity

The Printed Circuit Heat Exchanger (PCHE), first introduced by Heatric in 1985, is an established compact heat exchanger technology.

PCHEs have an unmatched capacity to undertake mechanically, chemically and thermodynamically demanding duties in limited space.

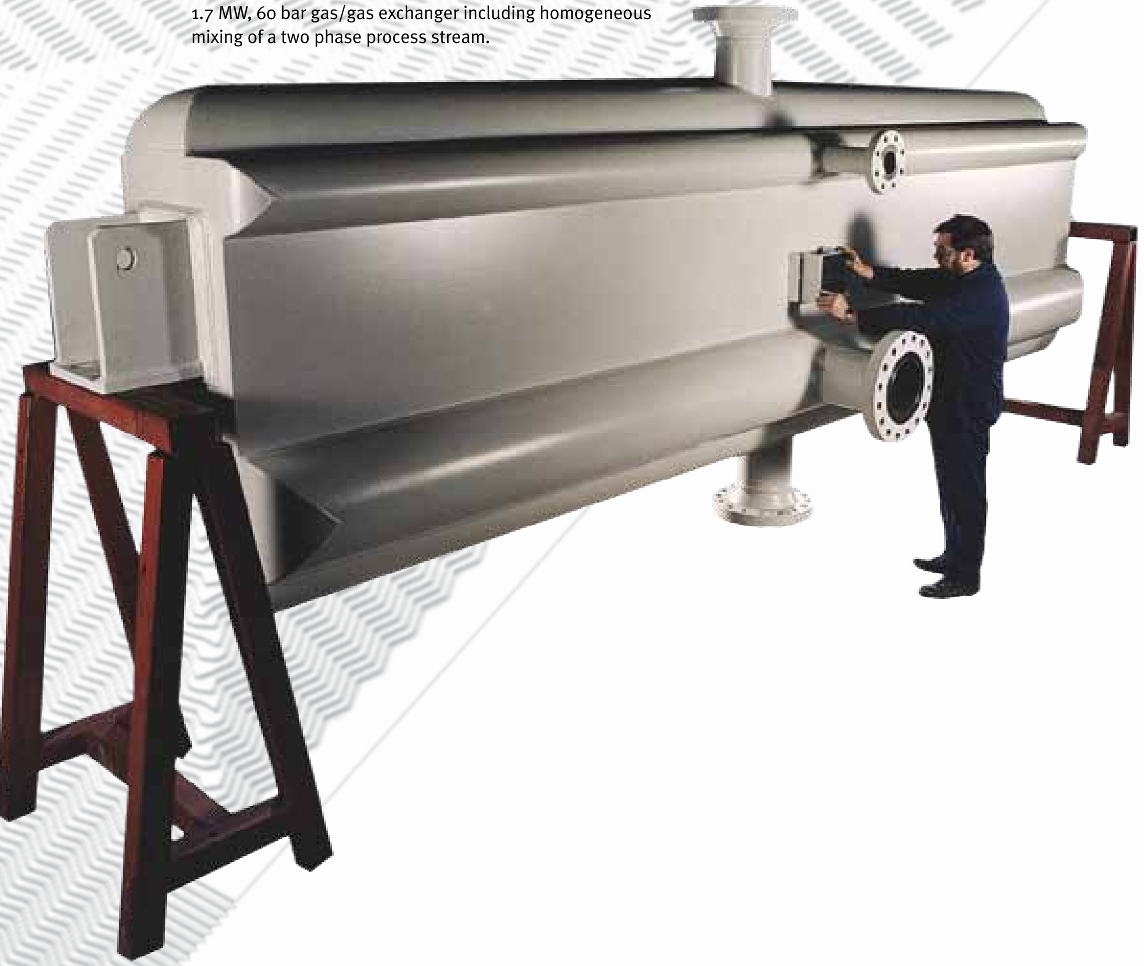
Through innovative design and a unique manufacturing process, Heatric produces high integrity heat transfer solutions, in close partnership with clients.

Flexible core orientation and nozzle design can further reduce space requirements. 2 x 11.2 MW gas coolers, 307 bar.

PCHE compression coolers, 450 MW total heat duty, were supplied to a Statoil development, giving a topsides weight saving of 2000 tonnes.

24 MW, 70 bar combined gas/gas and gas/condensate exchanger.

1.7 MW, 60 bar gas/gas exchanger including homogeneous mixing of a two phase process stream.



Heatric's performance as a supplier has consistently delighted customers over 20 years of manufacturing. This has been formally recognised with awards from several projects teams.

Construction

PCHEs are constructed from flat metal plates into which fluid flow channels are chemically milled. The chemical milling technique is similar to that employed for manufacturing electronic printed circuits. This method of manufacture gave rise to the name ‘Printed Circuit Heat Exchanger’.

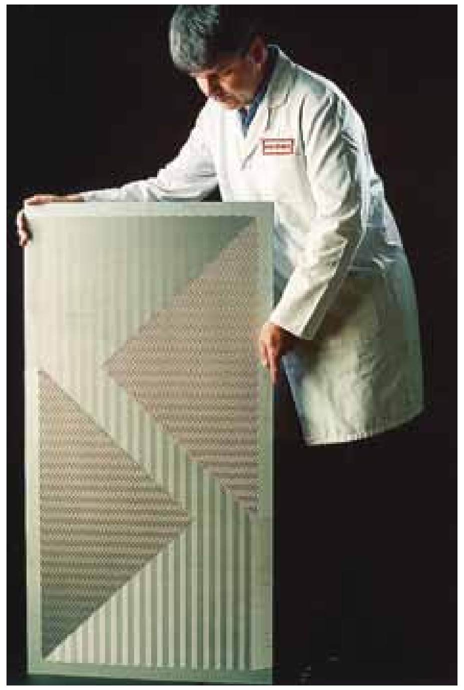
The milled plates are stacked and diffusion bonded together. Diffusion bonding is a ‘solid-state joining’ process entailing pressing metal surfaces together at high temperatures. This promotes grain growth between the surfaces, creating a bond of parent metal strength and ductility. Diffusion bonding thus converts stacks of milled plates into solid blocks containing precisely engineered fluid flow passages.

The blocks are then welded together to form the complete heat exchange core to meet the specified thermal duty. Finally, fluid headers and nozzles are welded to the core in order to direct the fluids to the appropriate sets of passages.

Materials

- Austenitic and duplex stainless steel
- Titanium
- Copper
- Nickel and nickel alloys

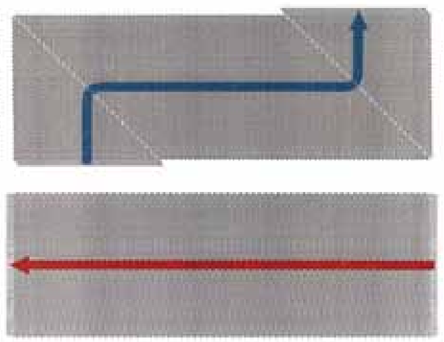
Construction in other suitable materials is also possible.



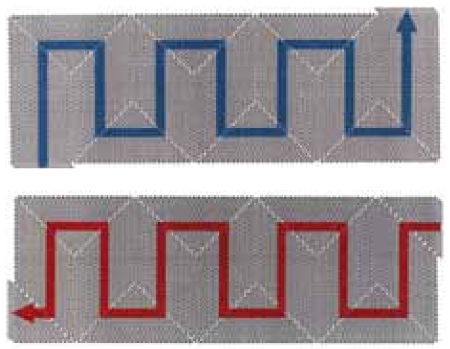
A typical 600 x 1200 mm plate

Stage 1: Plate design and manufacture

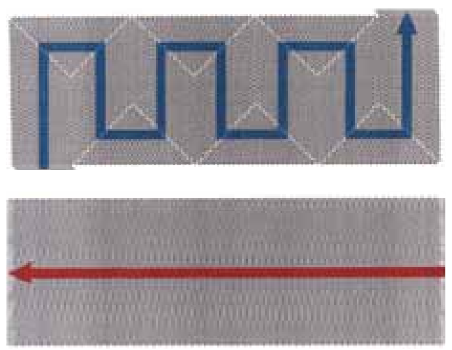
A versatile plate design and manufacture procedure means that a wide variety of flow schemes can be used in the PCHE core. The contact between fluids can be crossflow, counterflow, or combinations of these arrangements. Multi-pass schemes can also be used to increase effectiveness. More than one fluid can be accommodated on a single plate.



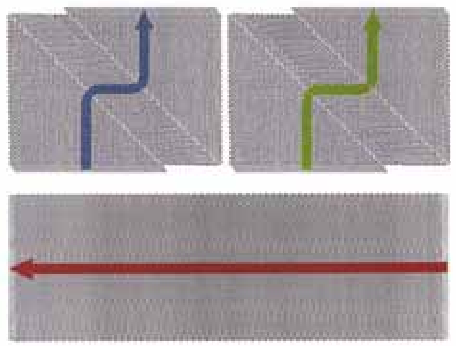
Counter flow



Multi-pass counter flow

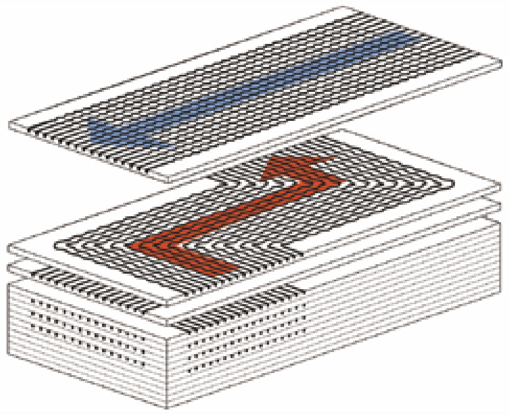


Multi-pass counter/cross flow



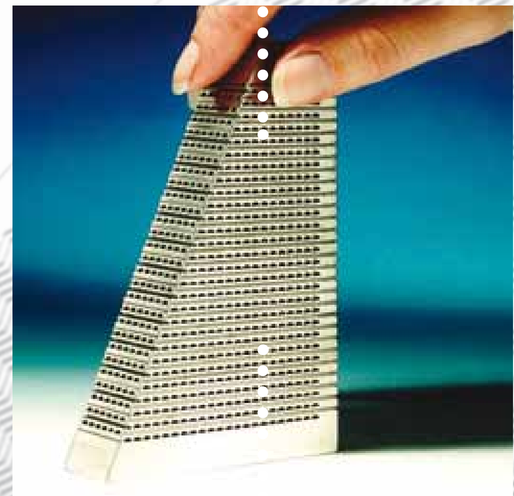
Multi-stream

Stage 2: Diffusion bonding

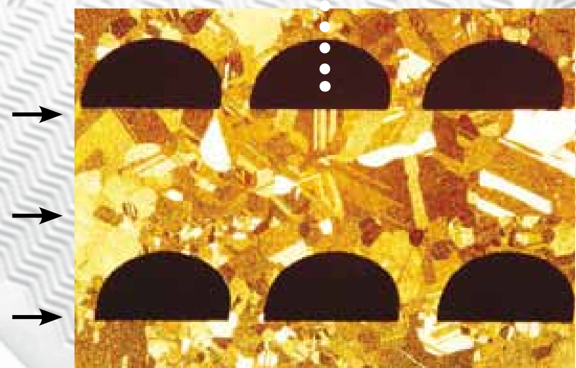


The plates are interleaved hot/cold/hot/cold... to achieve a high level of thermal contact between the fluids.

The stack of individual plates before diffusion bonding. Note the alignment of inlets on alternating plates down the front face.



Core Section
A section from a diffusion bonded PCHE core shows that it has become a ‘solid block with engineered passages’.



Micrograph
The etched cross-section shows grain growth across plate surfaces. There were four separate plates in this picture before bonding – the ‘crossflow’ passageway on the centre plate does not show. The arrows indicate locations of the plate surfaces before bonding.

Stage 3: Fabrication

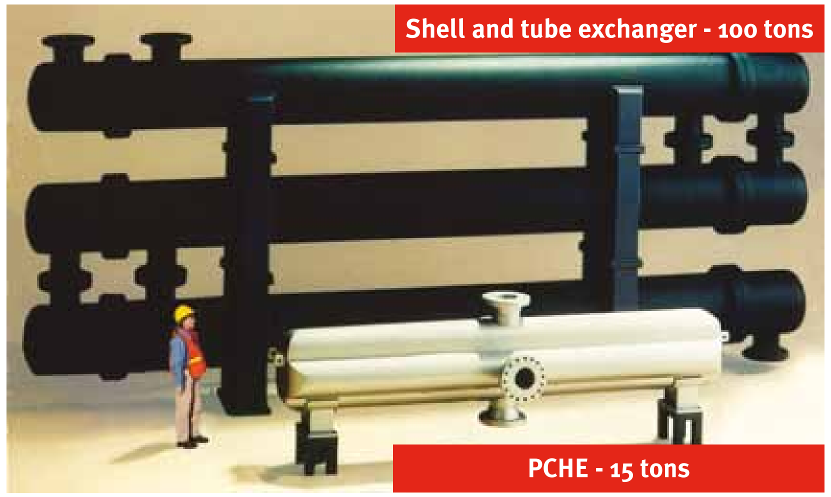
Individual diffusion bonded blocks are welded together to meet the full thermal duty. Finally headers and nozzles are attached.

Compactness

PCHEs are up to 85% smaller than shell and tube exchangers of equivalent performance (see example right). This is as a result of large heat exchange surface area per unit volume, high heat transfer coefficients, and high effectiveness counterflow contact in a single core.

Compactness lowers costs through:

- reduction in structural and support requirements
- easier installation
- easier transportation of skid mounted packages
- improved performance in limited space
- reduced fluid inventory



The PCHE in the foreground, as supplied to ARCO (see case study opposite) is 85% lighter than the stacked shell and tube exchangers behind, yet undertakes the same thermal duty at the same pressure drop.

Capabilities

High pressures

PCHE cores are readily designed for containment of exceptionally high pressures. PCHEs with design pressures of 500 bar (7500 psi) are in service (see graph to the right).

Extreme temperatures

Materials of construction such as austenitic stainless steel allow temperatures from cryogenic to ~ 800˚C (1500˚F).

Corrosive and high purity streams

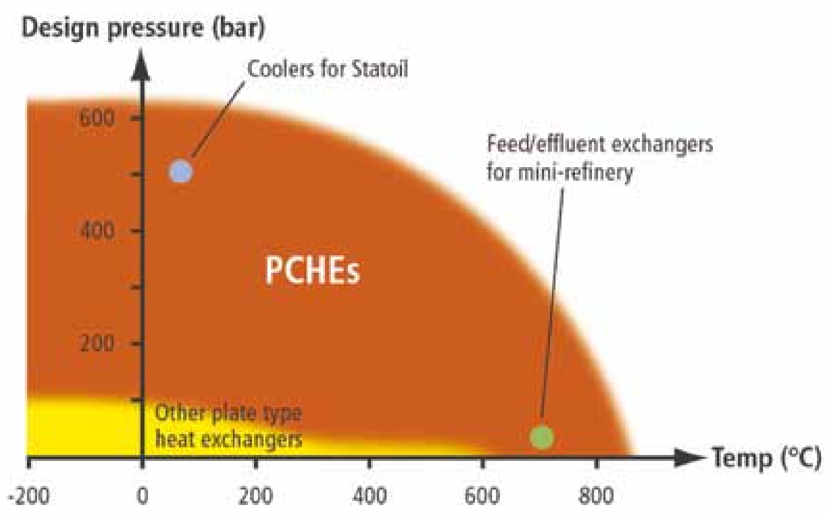
The construction technique is compatible with a wide range of corrosion resistant materials, and employs no braze alloy or gaskets.

Enhanced safety

PCHEs are not susceptible to hazards commonly associated with shell and tube heat exchangers, such as flow induced tube vibration and tube rupture. Overpressure relief systems can thus be substantially reduced. The highly compact nature of PCHEs also means that they have relatively low inventory, compared to shell and tube exchangers.

Flexible fluid pressure drop

Despite the compact nature of PCHEs, there is no restriction on the pressure drop specification for fluids passing through them, even with gases or highly viscous fluids. While the passages are small relative to conventional equipment, they are also short.



PCHE capability is shown here compared with plate type heat exchangers in common use: gasketed plate, brazed plate, welded plate and aluminium plate fin. Exact temperature and pressure limits depend on material of construction and design code.

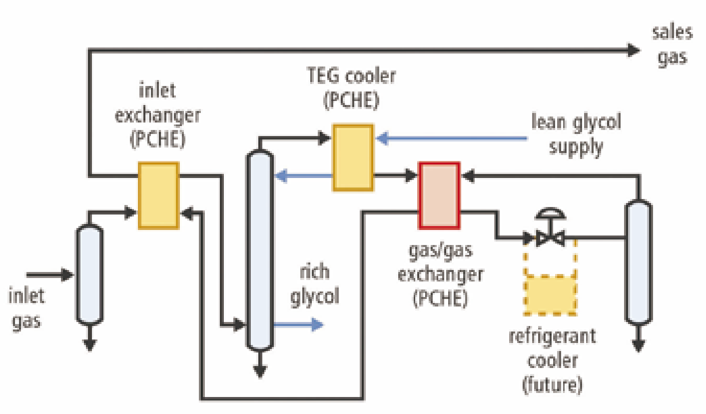
Case Study

BP (ARCO) has estimated that the use of PCHEs saved in excess of US$6 million on the onshore gas treatment plant at Pagerungan Island, Indonesia. This was achieved through reduced capacity requirements in other systems and space/ weight savings, when compared to the original shell and tube option.

BP's (ARCO) Pagerungan Island gas processing plant has two identical trains, each requiring three PCHEs: a gas/gas and gas/TEG for dehydration, and a gas/gas for J-T dewpoint control.

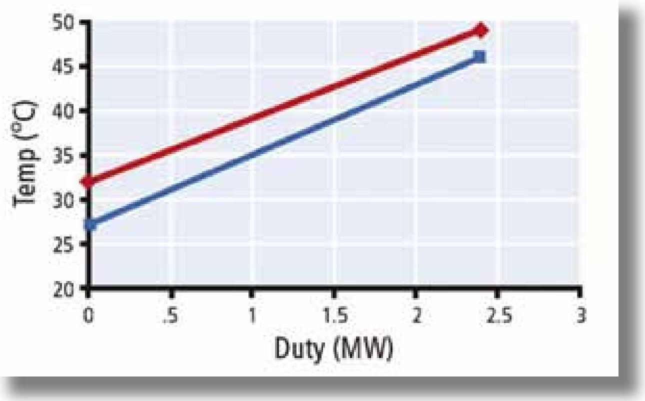
The gas/gas exchanger for J-T dewpoint control illustrated right and highlighted red on the process diagram, has a design pressure of 124 bar and a duty of 2.4 MW with a 4˚C LMTD. The high efficiency counter-flow contact achievable in PCHEs allowed a deep temperature cross in a single, compact unit, as shown by the temperature enthalpy curve. This meant that a planned refrigeration system was not required for the first few years of plant operation.

Also because this PCHE was 85% lighter than the shell and tube option, savings were made in transport, foundation and support.



One of two identical gas processing trains at Pagerungan Island

Gas/gas PCHE for J-T dewpoint control



Temperature enthalpy curve for the gas/gas PCHE used in J-T separation at Pagerungan.

Process Optimisation

Multi-stream capability

One of the features of plate type heat exchangers is that they are capable of containing more than two process streams in a single unit. PCHEs extend multi-stream capabilities to high temperature and pressure processes. Multi-stream heat exchangers have obvious space and weight advantages, through reduced exchanger and piping weight. Also, process control can be simplified or eliminated. Fluids can enter or leave the heat exchanger core at intermediate points, and can be contacted in series or in parallel, allowing flexibility in inlet/outlet temperatures.

Injection of fluids

The unique construction of PCHE cores enables accurate injection of one fluid into another, passage-by-passage.

Two-phase fluids

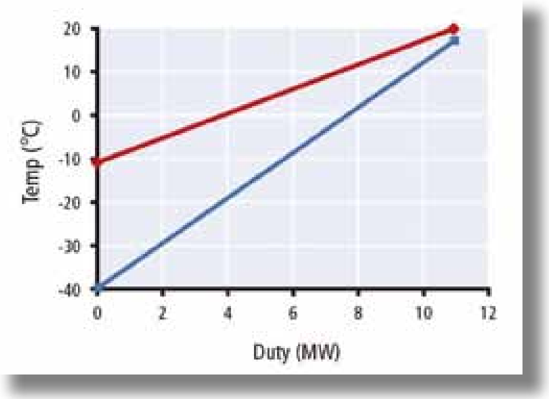
PCHEs handle boiling and condensation of fluids, and can also be employed in more complex duties involving absorption and rectification. It is also possible to evenly distribute two phase inlet streams in the PCHE core.

Functional integration

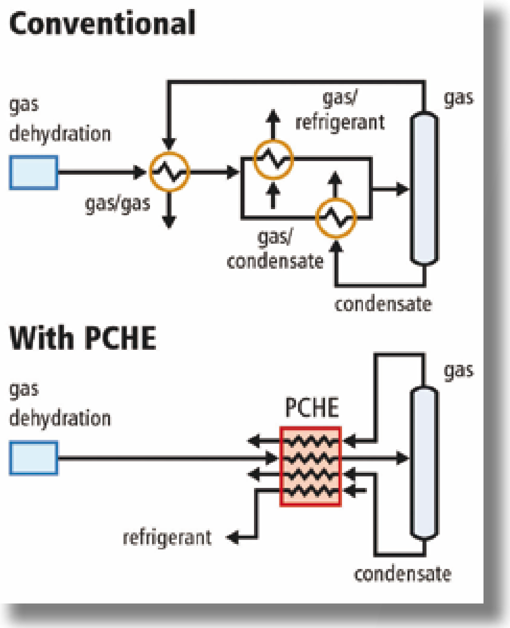
PCHE hardware is not restricted to heat exchange – it may also incorporate additional functions, such as chemical reaction, mass transfer and mixing.

High effectiveness

PCHEs have met process requirements for high thermal effectiveness in excess of 97% in a single compact unit. High effectiveness heat exchangers can reduce the duty, size and cost of other heating/cooling operations in the overall process scheme.

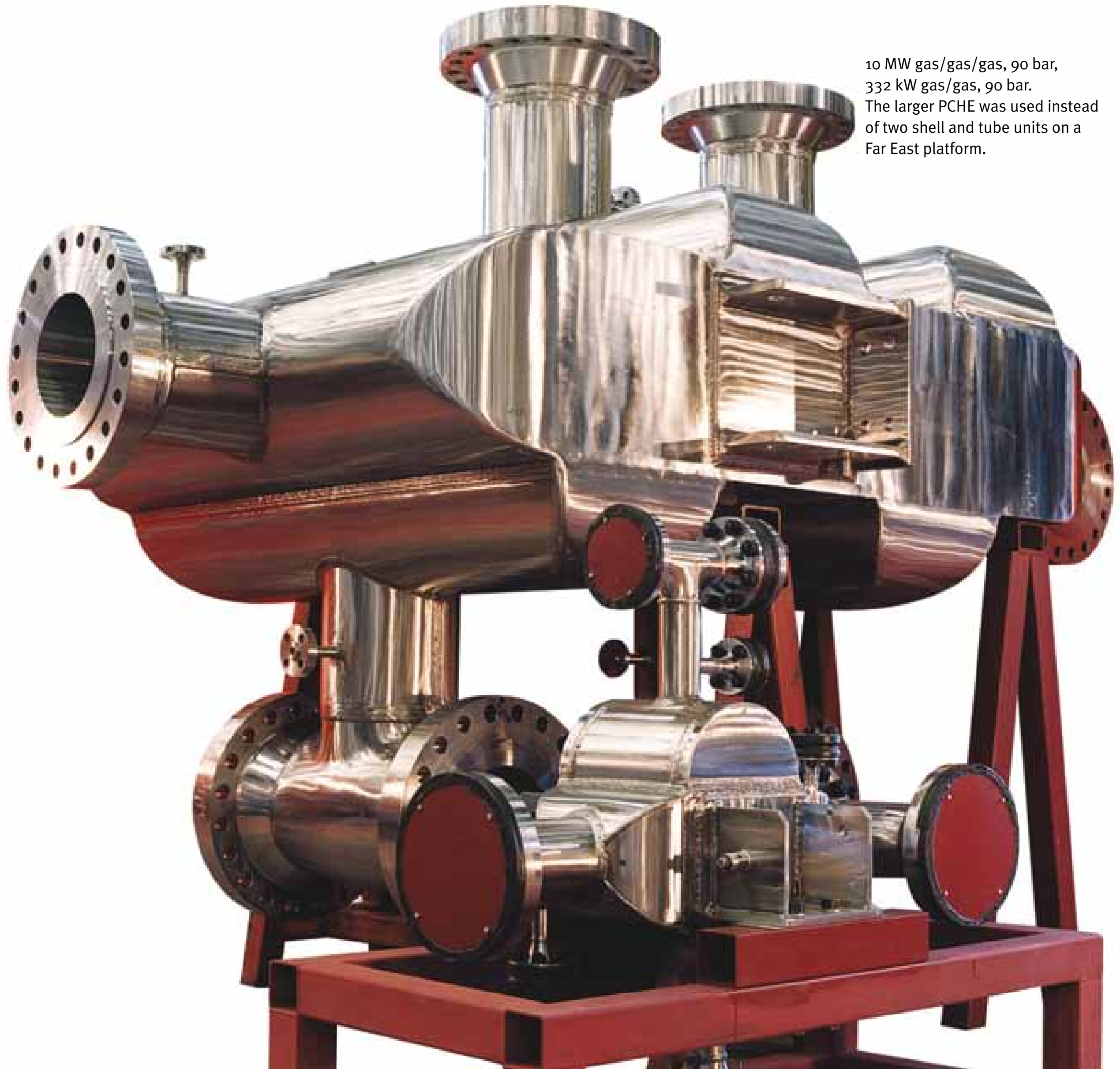


Four stream PCHE, duty 1.4 MW, pressure 66 bar



Gas/gas exchanger, 11 MW, 55 bar with 3˚C temperature approach. This exchanger was installed in a Joule-Thompson type gas dew pointing system offshore. The close temperature approach allowed a reduction in pressure let down necessary to achieve the low temperature required in the separator, while minimising space and weight.

PCHE multi-stream solution for retrofit gas dewpointing in severe space restrictions.



10 MW gas/gas/gas, 90 bar,
332 kW gas/gas, 90 bar.
The larger PCHE was used instead of two shell and tube units on a Far East platform.

Applications

Hydrocarbon gas and NGL processing

Gas processing – compression cooling, liquids recovery, dehydration

LNG and other cryogenic applications

Synthetic fuels production – methanol etc.

Air separation

Refining

Reactor feed/effluent exchangers

Chemical processing

Acids – nitric, phosphoric etc.

Alkalis – caustic soda, caustic potash

Fertilisers – ammonia, urea

Petrochemicals – ethylene oxide, propylene etc.

Pharmaceuticals

Plastics – formaldehyde, phenol etc.

Microtechnology

Chemical reactors

Power and energy

Geothermal generation

Nuclear applications

Fuel cells

Fuel gas heating – gas turbines

Refrigeration

Chillers and condensers

Cascade condensers

Absorption cycles

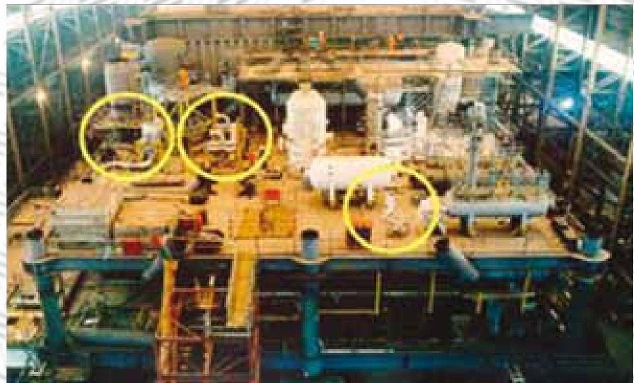
Operation

PCHEs have no parts requiring routine service or replacement. PCHEs are suitable for relatively clean fluids. During operation, particle size entering the exchanger should be limited to 300 microns. PCHEs are resistant to the build up of surface deposits through consistently high wall shear stresses and no fluid flow dead spots.

PCHE installation on a South China Seas platform

Compact compressor skids each compressing 20 mmscfd gas to 175 bar. Photo courtesy of Enerflex Ltd.

PCHE use on BG Armada saved 3 metres on each of three decks, and enabled single lift installation. The project team estimated GB£10 million (approx. US$15 million) was saved on overall project costs.



PCHE installation on BG Armada platform.

BG Armada platform.