Compact Platelet Heat Exchangers

Innovative Thermal Management Solutions

A division of Clean Energy Systems, Inc.
HEXCES designs, develops, and manufactures thermal management systems to meet customer needs. Specifically, we focus on **compact platelet heat exchangers, or CPHXs**. These devices are used to transfer energy in the form of heat from one or more fluid streams to another without any mixing of the fluids.

Platelet technology allows for small fluid passages that provide maximum heat transfer surface area in an extremely compact space; **increasing exchanger effectiveness** while **minimizing its weight and footprint**. CPHXs can range from a few grams to multiple tonne assemblies.

All of HEXCES CPHXs are designed and built to ASME Boiler and Pressure Vessel Code Section VIII, Division 1.

**Benefits of Compact Platelet Heat Exchangers**

- **Material of Construction**
  - Stainless Steel
  - Nickel Based Alloys
  - Cobalt Based Alloys
  - Copper
  - Titanium
  - Refractory Materials
  - And More

- **Multiple Fluid Streams Possible**
  - Gases, Liquids, and Two-Phase Flows
  - Cross, Counter, and or Co Flow

- **Thermal Effectiveness**
  - Unmatched Surface Area per Unit Volume
  - High Heat Transfer Coefficients Achievable with Small-Hydraulic Diameter Flow Passages
HEXCES CPHX Examples

Superheater CPHX
Heat Rate – 0.5 MW
Working Temperature – 650°C
Working Pressure – 100 bar
Core Dimensions – 29cm x 30cm x 15cm
Core Material – Inconel 600
Manifold Material – Inconel 600

Preheater CPHX
Heat Rate – 1.4 MW
Working Temperature – 300 °C
Working Pressure – 110 bar
Core Dimensions – 57cm x 30cm x 12cm
Core Material – 316L SS
Manifold Material – Inconel 600

Formed Liner CPHX
Heat Flux - 13 kW/cm²
Working Temperature – 1500 °C
Working Pressure – 110 bar
Core Dimensions – 10cm ID x 12cm OD x 54cm
Core Material – Inconel 600 / Hastelloy C22 Hot Gas Wall
Manifold Material – 316L SS
The HEXCES test facility, wholly owned and operated by parent company Clean Energy Systems, is the world’s largest pressurized oxy-fuel combustion test facility. The 40-acre site is laid out for R&D, sub-scale, and commercial-scale operations. **Major features include:**

- Dedicated Heat Exchanger Test Bed
- CES 20 MWt Oxy-Fuel Gas Generator
- CES 200 MWt Oxy-Fuel Gas Generator
- CES 30 MWe OFT-J79 Expander Turbine
- CES 150 MWe OFT-900 Expander Turbine
- SAGD Gas Generator and Steam Separator
- Full-Scale Steam Reheater Test Bed
- 100% Carbon-Capture-Ready, 5 MWe Steam Turbine Cycle; Suitable for Continuous Operations, Producing 1,500 Mscfd CO$_2$
Services

HEXCES offers a variety of services to assure quality, performance, and customer satisfaction.

Applications Engineering
Field Services
  Installation & Commissioning Support
  Product Inspection & Maintenance
  Decommissioning Support
New Product Development
Performance Testing
Repairs and Maintenance
Systems Design Engineering

Markets

HEXCES provides innovative solutions for complex thermal problems across multiple markets.

Oil and Gas, On and Off-shore

Gas Compression Coolers
High Temperature Recuperators
Inlet, Suction, Discharge, and After Coolers
Liquefied Petroleum Gas Exchangers
Natural Gas
  Liquefaction and Regasification
  Preheaters
  Superheaters
  Synthetic Fuel Production

Power Generation

Feedwater Heaters
Fuel Gas Heaters and Preheaters
Molten Salt Applications
Organic Rankine Cycle Exchangers
Pressurized Boilers
Ultra and Super Critical CO₂ Exchangers

Aerospace

Propulsion System Exchangers
Satellite System Exchangers

Chemical Processing

Mixers
Reactors

Cryogenics

Liquid Helium Exchangers
Liquid Hydrogen Exchangers
Liquid Natural Gas Exchangers
Liquid Nitrogen Exchangers
Liquid Oxygen Exchangers
Technology

Overview

The compact platelet heat exchanger (CPHX) utilizes platelet technology, developed in the aerospace industry. The resulting process allows the fabrication of monolithic structures containing complex and precise, 3D flow passages and features.

Platelet Technology

Platelet technology provides solutions to difficult thermal and fluid flow problems across a variety of market applications. The process begins with thin sheets of metal that are photo-chemically etched with specific design patterns to produce “platelets.” Individual platelets are then accurately assembled, or “stacked,” and joined via a diffusion bonding process. The result is a monolithic structure containing complex internal passages that allow for precise flow control, fluid manifolding and metering features. The diffusion bonding process effectively seals the passages between the fluid circuits with a solid metal barrier, isolating and segregating flows. This allows for much higher operating pressures and temperatures than achievable with traditional heat exchangers.
Diffusion bonding is a solid state process, i.e. no melting takes place, that produces a monolithic joint through the formation of bonds at the atomic level.

The mating surfaces of the platelets are forced into intimate contact due to local plastic deformation at elevated temperatures; elemental diffusion across the platelet interface begins, along with grain boundary migration. At the completion of the process, all surface layers of the platelets are joined through inter-diffusion and the original interfaces and boundaries are fully coalesced, creating a singular device. When performed with HEXCES developed parameters, no macro-scale deformation occurs during the bonding process, leaving the as-fabricated platelet features intact with essentially parent material strength. These assemblies cannot be fabricated by any other current conventional or unconventional process.

Stages of Diffusion Bonding

Initial Platelet Contact → Plastic Deformation / Interfacial Boundary Formation → Creep Deformation / Boundary Migration → Volume Diffusion / Void Elimination

Micrograph of a diffusion bonded 300 series stainless steel part; the microstructure shows grain boundary propagation across the five platelet interfaces.