ATMOsphere ASIA
technology & innovation
natural refrigerants
3-5 February 2014, Tokyo

A NOVEL DESIGN OF COMPACT BRAZED PLATE HEAT EXCHANGER FOR CO2 TRANSCRITICAL APPLICATIONS

SWEP
A DOVER COMPANY

Why CO_2 ?

#1

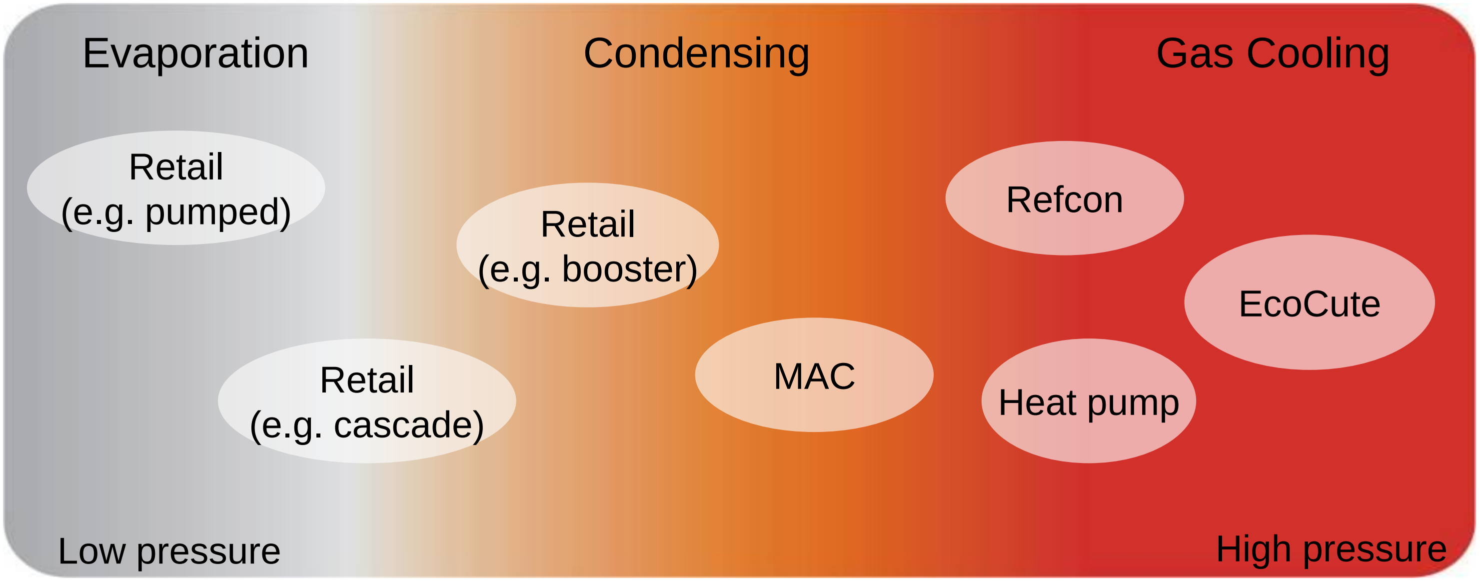
Non-toxic, non-flammable.

Non-ozone-depleting

Environmentally friendly with GWP=1

Suitable for both transcritical and subcritical systems depending on application; focus either on heating or cooling

High cycle pressure → high fluid density throughout the cycle allowing smaller systems



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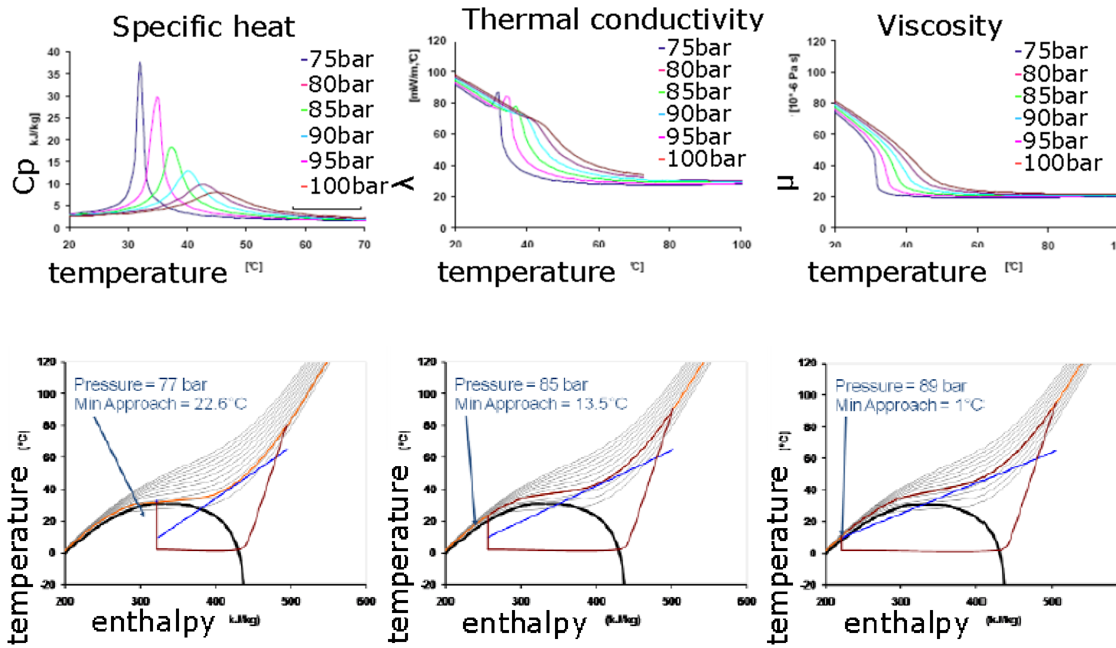
CO2 transcritical properties

#2

- Transcritical situation- high pressure
- Properties transfer non-linearly as temperature varied
- lower operating pressures problems with temperature pinches through the BPHE increases
- Small temperature difference require more heat transfer area



CO2 in transcritical properties and temperature approach inside heat exchanger

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Gas cooler analysis

#3

Existing BPHE

- CO_2 has larger pinch temperature difference
- CO_2 need larger heat transfer area
- CO_2 is not sensitive to pressure drop

Gas cooler performance at different refrigerants

		R410A	R22	CO2
refrigerant side	operating pressure (MPa)	3.78	2.56	12.5
	inlet temperature(°C)	81.3	81.3	81.3
	outlet temper (°C)	17	17	17
water side	inlet temperature(°C)	17	17	17
	outlet temper (°C)	65	65	65
performance	heat load (kW)	2		
	Pinch temperature(K)	3.8	2.0	6.0
	Pressurer drop (kPa)	0.15	0.55	0.16
Heat transfer area (m^2)		0.27	0.27	0.27

Gas cooler analysis

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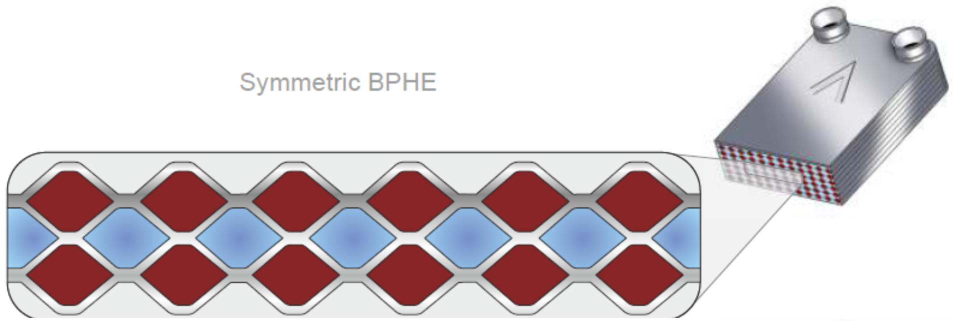
water side	inlet temperature(°C)	17	17	17
	outlet temper (°C)	65	65	65
performance	heat load (kW)	2		
	Pinch temperature(K)	3.8	2.0	1.0
	Pressurer drop (kPa)	0.15	0.55	10.8
Heat transfer area (m^2)		0.27	0.27	0.27

New BPHE request

Longer thermal length

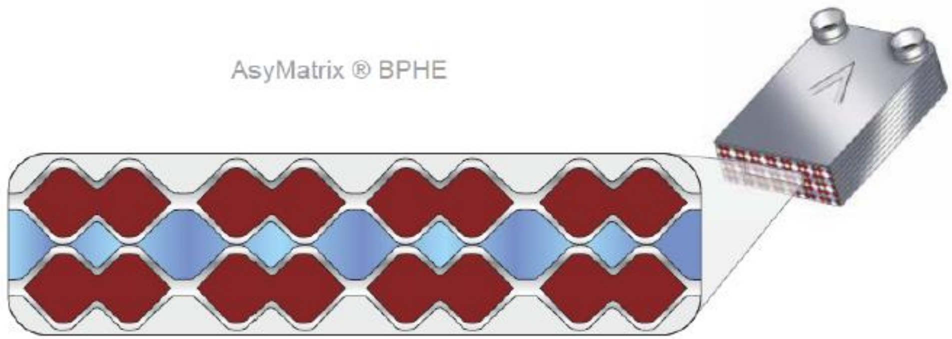
Asymetrix technology



Conventional BPHE

Symmetric pattern - Generic

Side 1 = Side 2



AsyMatrix BPHE

Tailored pattern - Optimized

Side 1 ≠ Side 2

AsyMatrix® BPHE advantages over symmetric BPHE technology

Improved heat transfer – increasing system thermal performance

Lower pressure loss – reducing pump work

Improved Mechanical strength – stronger units

Greatly reduced dimensions – allowing for smaller system solutions

Lower hold up volume – reducing refrigerant costs

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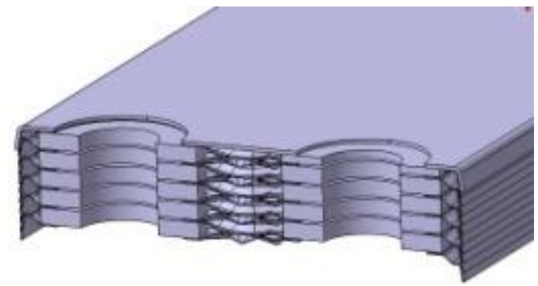
BPHE structure for high pressure CO2 application

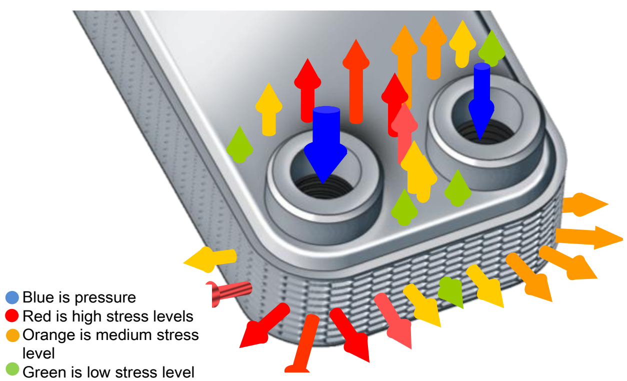
#6

a: external support

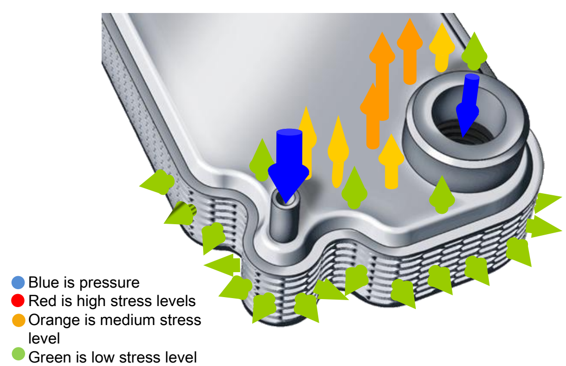


b: internal support

Conventional BPHE structure for high pressure design

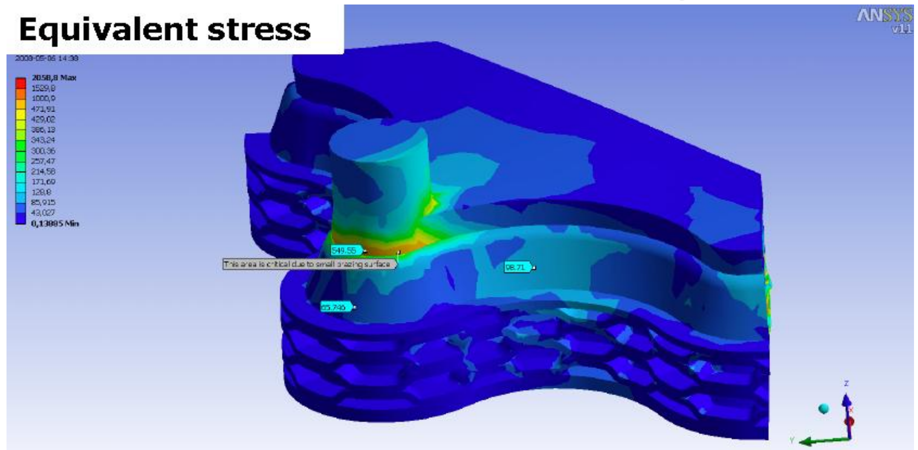


Conventional structure stress distribution at port area

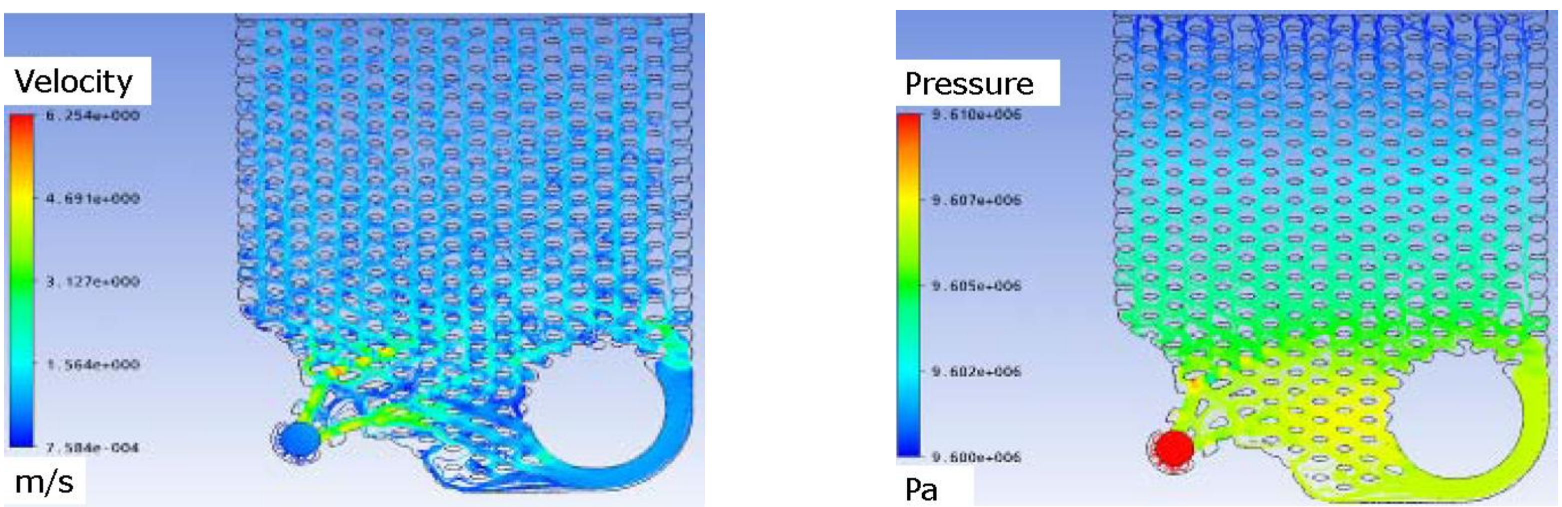


New design stress distribution at port area

FEM and CFD simulation for structure design



Equivalent stress at the corner part analysis using FEM



CFD results of channel velocity and pressure distribution

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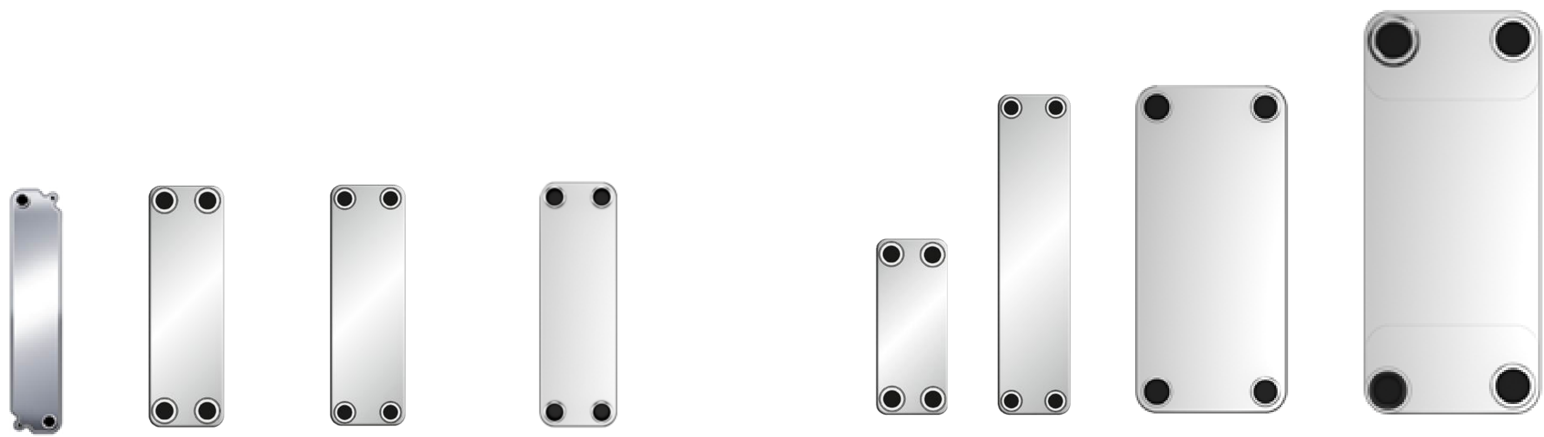
Dedicated BPHE's for CO_2-applications

#8

Gas coolers (Supercritical operation)

Evaporators (Subcritical operation)



B9SW
Dimensions
78x378

B16DW
Dimensions
119x377

B17SW
Dimensions
119x377

B18SW
Dimensions
119x377

B12H
Dimensions
117x287

B25H
Dimensions
117x524

B120TH
Dimensions
243x525

B400TH
Dimensions
304x694

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CO2-heat recovery for IT Datacenter

#9

Design Data:

Capacity: 100-200kW

Water temperature: 40 – 70° C

Design pressure: up to 130 bar

COP: @ source temp: 10-20° C: 3,6-4,0

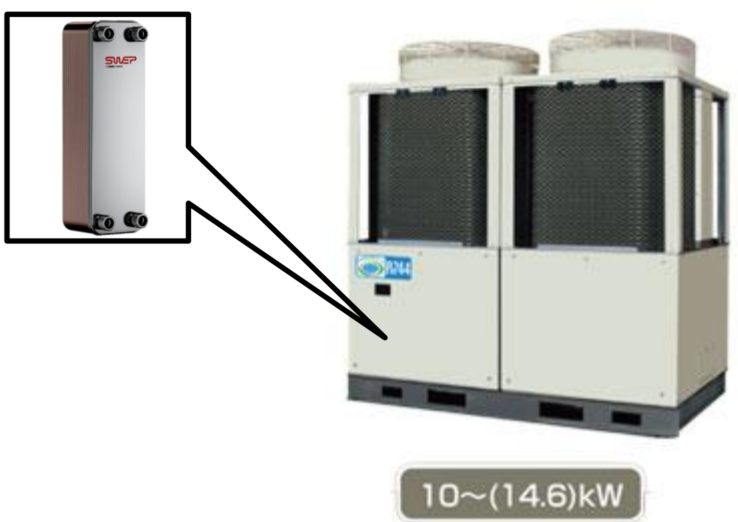
Supercritical CO2 refrigeration-challenge

#10

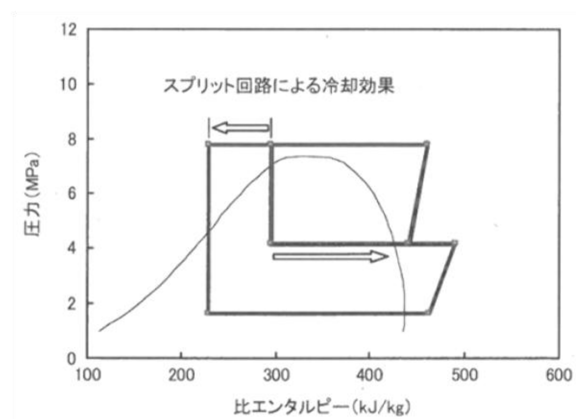
To improve performance, design a compact, high pressure CO2 economizer

Solution

B17 adopted in the system



Panasonic CO2 refrigeration



Economizer function in the system

Resource: NEDO site

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Thank you very much!

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