

A new CAPE-OPEN Unit Operation Module for Simulation of Brazed Aluminium Plate-Fin Heat Exchangers

D. Averous, O. Baudouin, S. Déchelotte, R. Egal,
F. Picard, R. Sardeing, A. Vacher



#710h - Advances in Information Management and Integration
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Outline

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- ▣ What is a “Brazed Aluminium Heat Exchanger”?
- ▣ What is CAPE-OPEN?
- ▣ What is CO-ProSec?
 - ▣ Accurate and robust model
 - ▣ CAPE-OPEN compliant software
 - ▣ Easy-to-use software
- ▣ Application example

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What is a BAHX?

Heat Exchanger
Aluminium
Brazing
Multi-streams
Cryogenic industries

Temperature: -270°C to 65°C
 Pressure: up to 140bars

Dimensions max.
 8m x 1.3m x 2m


Compact

Efficient

Light

Multi-chamber
 Pressure vessels

Good mechanical
 characteristics



Manifolded cores




Cold box transportation



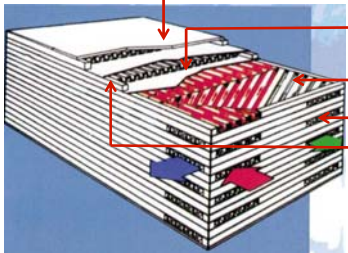
A BAHX core

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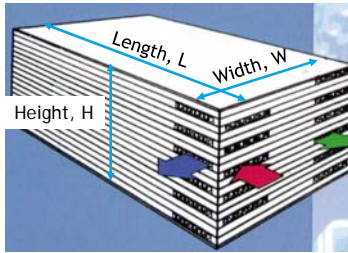


What is a BAHX?

Components of BAHX

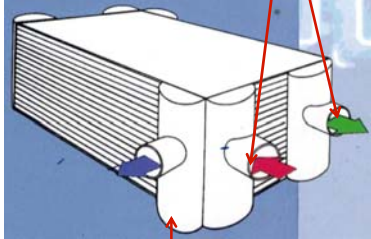


- Cap sheet
- Parting sheet
- Fins (distributors, heat transfer)
- Distributor
- Side bars



Length, L
Width, W
Height, H


Block (core)



Nozzles

Headers

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What is a BAHX? Brazing

Vacuum brazing furnace
Brazing Temperature ~ 620°C/1150°F

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What is a BAHX? Fin corrugations - Principal types of fin

Plain fins

Plain-perforated fins

Serrated fins

Herringbone or wavy fins

Figures are from ALPEMA's standard (www.alpema.org)

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What is a BAHX?


Applications - A wide range of use

Air

Hydrocarbons

Chemicals

Cold boxes: Air separation, Ethylene, Natural gas...



"Core in Drum": Heater, chiller, boiler



On board Reliquefaction, FLNG systems




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What is CAPE-OPEN?
Interoperability between software

Computer Aided Process Engineering (CAPE)

- In simulation software, a lot of software components interact together...
- ... and they are strongly inter-linked!!!
- Limits of these components are not always well defined!!!
- Needs for interoperability between software (e.g.: use Pro/II with Aspen's U.O and ProSim's thermodynamic model)


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What is CAPE-OPEN?
Interoperability between software


CAPE-OPEN defines interfaces

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What is CAPE-OPEN? Interoperability between software


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Areas covered



Unit
Operation




Numerical
Solver




Process Modeling
Environment

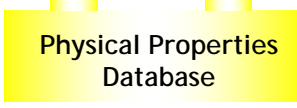
M
I
D
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L
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W
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R
E



Thermodynamics
Server




Reactions




Physical Properties
Database





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What is CAPE-OPEN? Interoperability between software



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History of the CAPE-OPEN specifications

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	... today
OO-CAPE <i>Developing the concept (1)</i>											
OS-CAPE <i>Developing the concept (2)</i>											
CAPE-OPEN <i>Proving the concept</i> 											
Global CAPE-OPEN <i>Implementing the technology</i>  											
CO-LaN <i>Maintaining the standard</i>											
GCO Support <i>Disseminating results</i> 											


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What is CAPE-OPEN?


Advantages of CAPE-OPEN


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-  No coding of interface required
-  You can continue using your favorite thermo package or unit operation or process simulation software without any programming effort
- ⇒ An open system to value your earlier investments
-  ProSim has been an early member of the CAPE-OPEN initiative
-  ProSim is the only software provider implementing
 - Unit Operation "Socket"
 - Thermodynamic Plug (1.0 and 1.1)
 - Thermodynamic Socket (1.0 and 1.1)








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What is CO-ProSec?

Product of partnership

⇒ **Making the most of R&D resources to deliver commercial results**

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ProSim

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What is CO-ProSec?

Product of several years of research

- 4 PhD Thesis (FivesCryo/LGC/ProSim):
 - Hervé PINGAUD (1985-1988)
 - David AVEROUS (1997-2000)
 - Khaled HAMMADI (1998-2001)
 - Florian PICARD (2005-2008)
- 30 years of development

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ProSim

What is CO-ProSec?

A very detailed and accurate model

2D representation of BAHX

- Length and height are considered
- Real stacking is taken into account
- Streams:
 - temperature, enthalpy, pressure
- Sheets (walls):
 - temperature

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What is CO-ProSec?

A very detailed and accurate model

Model is based on:

- Conservation laws for mass, momentum and energy
- Heat is transferred between adjacent passages:
 - through the separating plates
 - by conduction through the fins

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What is CO-ProSec?

A very detailed and accurate model

User has to provide the topology of the BAHX:

- Description of the reference layers (geometry, fins, streams)
- Stacking definition

L1
L3
L1
L4
L2
L3
L1
L3
L1
L4
L2
L3
L1
L3
L1
L4
L2
L3

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What is CO-ProSec? An application example (Averous, 2000)

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What is CO-ProSec? An application example (Averous, 2000)

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Name	Reference #	Origin	Reynolds numbers	Finning coefficient	Colburn coefficient
1001	2011	User	46	0.58074	0.00258
2830	2219	Standard database	122	0.39326	0.04122
			200	0.26353	0.03266
			528	0.14066	0.02040
			881	0.113	0.01643
			1442	0.09665	0.01337
			2363	0.08753	0.01106
			6338	0.0818	0.00797
			17003	0.08171	0.00604
			49614	0.0726	0.00462

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What is CO-ProSec?
 An application example (Averous, 2000)

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Name	Color
A	Red
B	Blue
C	Blue
D	Blue
E	Blue
F	Blue

Main fn: 1001
 PORT fn: 1001
 TURN fn: 1001
 SIO fn: 1001
 Number of heads: 1
 Number of pricking: 1
 Pricking opening: 250 mm
 Pricking height: 250 mm
 Pricking diameter: 0 m
 Stream #1: S01
 Stream #2: S01

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What is CO-ProSec?
 An application example (Averous, 2000)

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Layers summary

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What is CO-ProSec? An application example (Averous, 2000)

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What is CO-ProSec? An application example (Averous, 2000)

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Sequence 1

Sequence 2

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What is CO-ProSec?

An application example (Averous, 2000)

Stream	Input T (°C)
S01	39.85
S02	-185.55
S03	-168.15
S04	-168.15
S05	-176.35
S06	-179.05

Sequence 1 simulation results					
Stream	Output temperatures (°C)			Differences (°C)	
	Spec	CWT	CO-ProSec	CWT - CO-ProSec	CO-ProSec - Spec
S01	-159.00	-162.31	-156.32	-5.99	2.68
S02	35.00	36.26	38.83	-2.57	3.83
S03	35.00	35.13	31.02	4.11	-3.98
S04	35.00	35.13	32.66	2.47	-2.34
S05	35.00	35.55	34.73	0.82	-0.27
S06	35.00	35.95	37.31	-1.36	2.31

Sequence 2 simulation results					
Stream	Output temperatures (°C)			Differences (°C)	
	Spec	CWT	CO-ProSec	CWT - CO-ProSec	CO-ProSec - Spec
S01	-159.00	-162.37	-160.17	-2.20	-1.17
S02	35.00	36.31	37.28	-0.97	2.28
S03	35.00	35.23	36.56	-1.33	1.56
S04	35.00	35.21	36.51	-1.30	1.51
S05	35.00	35.53	36.65	-1.12	1.65
S06	35.00	35.84	36.39	-0.55	1.39

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What is CO-ProSec?

An application example (Averous, 2000)

Sequence 1: wall temperature analysis

Wall number	Cold ambient (°C)	Hot ambient (°C)	Media (wall - 2014.35)	Maximum Outlet
1	-161.96914260210	16.829195519842	32.827897714488	28.182771848467
2	-161.171962627170	16.846222222222	32.762437848488	28.184719428462
3	-161.193487918428	16.2102026671387	28.715388155484	25.421345237154
4	-161.538116611467	16.318457943887	28.228818527158	21.586625641161
5	-161.53815544124	16.348111272287	28.214254848417	22.86284451758
6	-164.088778482118	16.328888888889	-36.828191827827	23.821124818438

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What is CO-ProSec?

An application example (Averous, 2000)

Sequence 2: wall temperature analysis

Wall number	Cold ambient (°C)	Hot ambient (°C)	Middle (m)	Maximum DeltaT
1	488.801704847112	12.8270220291612	-146.20002701818	488.988682826315
2	488.281167788184	12.7076179203424	-85.2200271976259	488.608807200315
3	488.12202701818	12.8270220291612	-85.2200271976259	488.307648148115
4	488.801704847112	12.8270220291612	85.2200271976259	488.514122029161
5	488.281167788184	12.8270220291612	85.2200271976259	488.307648148115
6	488.12202701818	12.8270220291612	146.20002701818	488.988682826315


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Thank you for your attention!

... any question?

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Computer Aided Process Engineering Process Engineering Studies and Software



ProSim SA
 51, rue Ampère
 Immeuble Stratège A
 F-31670 Labège Cedex
 France

Phone: +33 (0) 5 62 88 24 30
 Fax: +33 (0) 5 62 88 24 39

www.prosim.net
info@prosim.net



ProSim, Inc.
 Science Center
 3711 Market street, 8th floor
 Philadelphia, PA 19104
 U.S.A.

Phone: +1 215 600 3760
 Fax: +1 215 600 3759

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