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

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ProSim
Software & Services in Process Simulation

Outline

- 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

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

Low pressure drops | Low pinch

Multi-chamber Pressure vessels

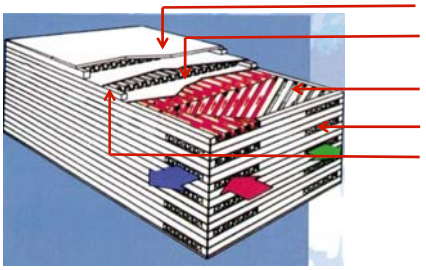
Good mechanical characteristics

Manifolded cores

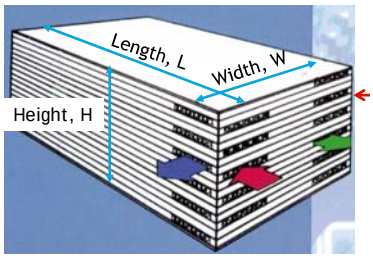
Cold box transportation

A BAHX core

What is a BAHX?
Components of BAHX

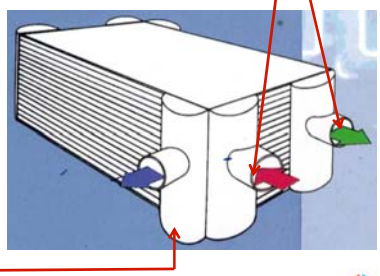


Cap sheet
Parting sheet
Fins (distributors, heat transfer)
Distributor
Side bars



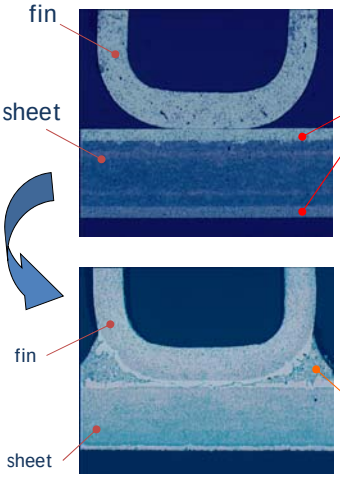
Block (core)

Nozzles



Headers

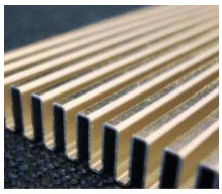
What is a BAHX?
Brazing

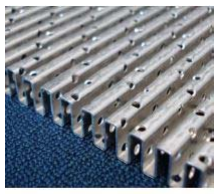


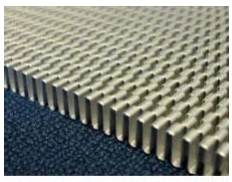
Vacuum brazing furnace

Brazing Temperature ~ 620°C/1150°F

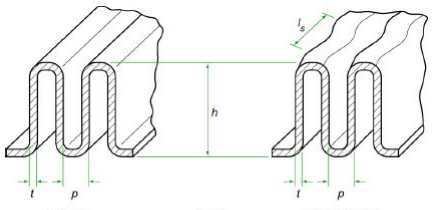
What is a BAHX?
Fin corrugations - Principal types of fin

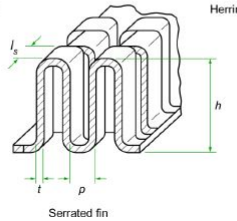

Plain fins


Plain-perforated fins


Serrated fins


Herringbone or wavy fins





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

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 systems Reliquefaction, FLNG

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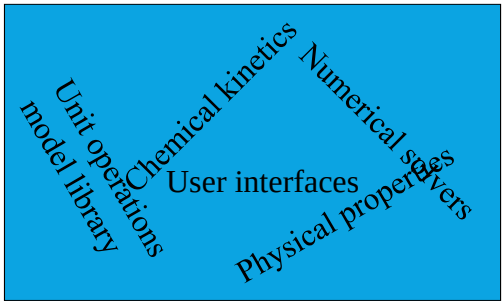
  - Easy-to-use software
- Application example

What is CAPE-OPEN?
Interoperability between software

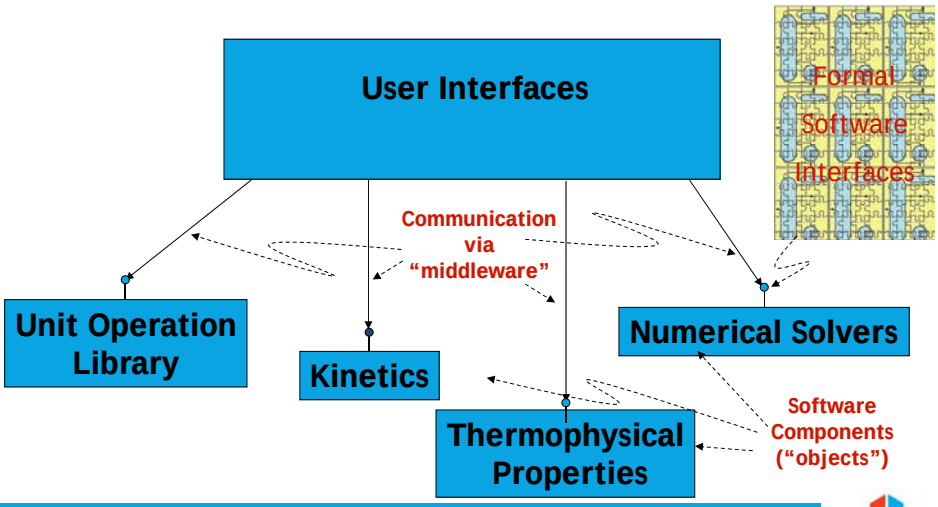
- Computer Aided Process Engineering (CAPE)



- 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)

What is CAPE-OPEN?
Interoperability between software

- CAPE-OPEN defines interfaces



What is CAPE-OPEN?
Interoperability between software

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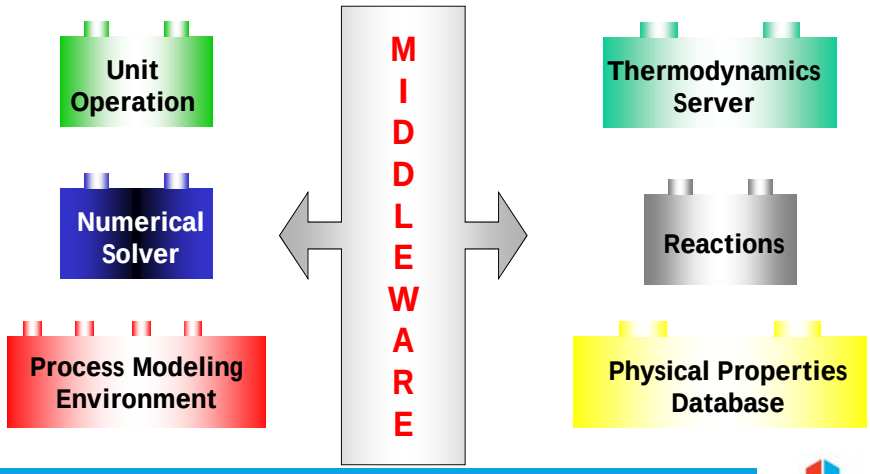
Areas covered



What is CAPE-OPEN?
Interoperability between software

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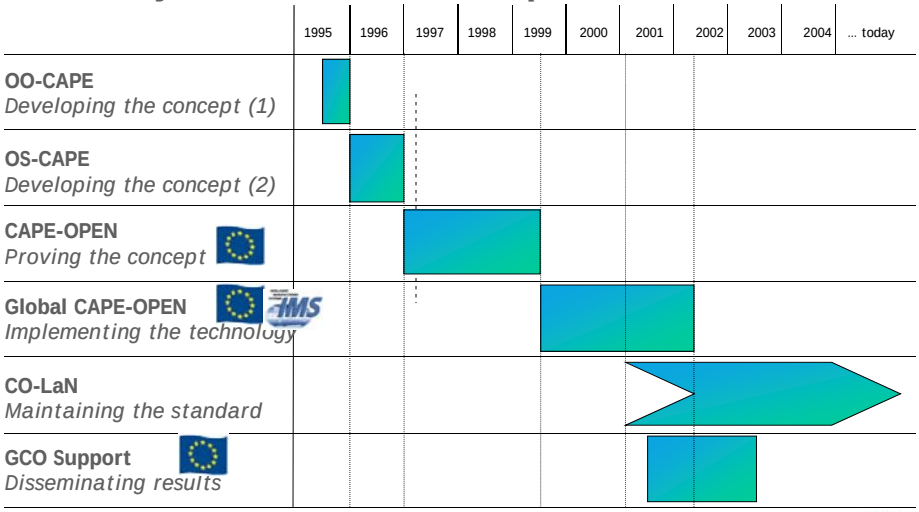
History of the CAPE-OPEN specifications



What is CAPE-OPEN?
Advantages of CAPE-OPEN

- 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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  - **CAPE-OPEN compliant software**
  - **Easy-to-use software**
- Application example

What is CO-ProSec?
Product of partnership

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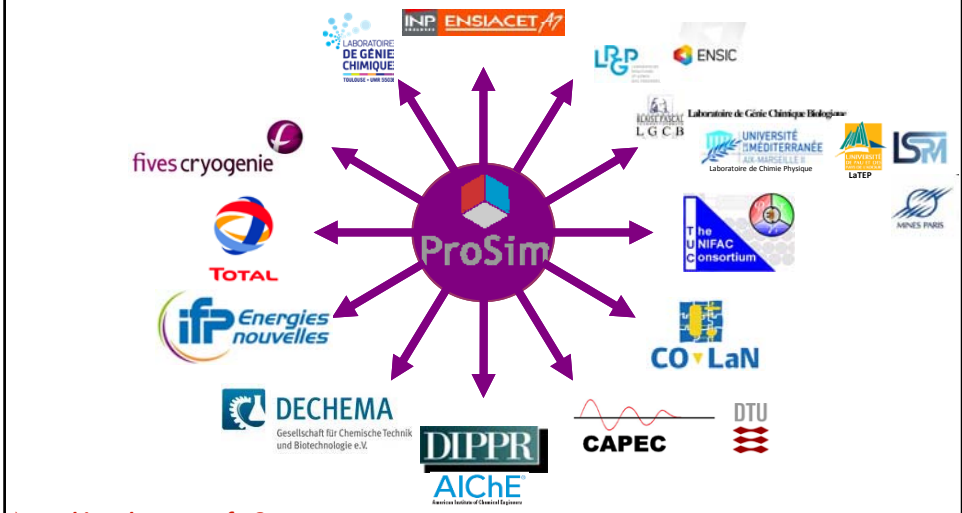

⇨ *Making the most of R&D resources to deliver commercial results*

What is CO-ProSec?
Product of several years of research

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- **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**

fives cryogenie

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ProSim

What is CO-ProSec?
A very detailed and accurate model

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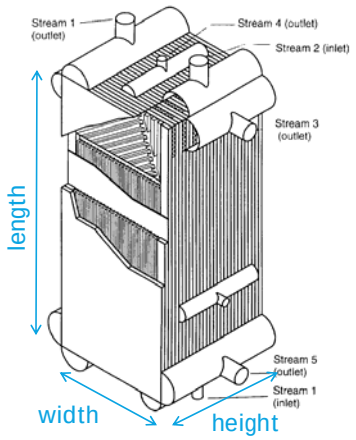
- **2D representation of BAHX**



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

What is CO-ProSec?
A very detailed and accurate model

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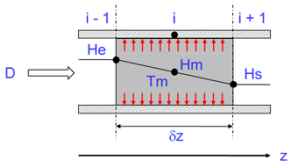
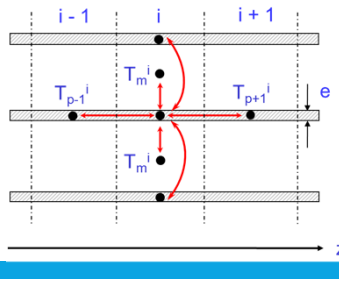
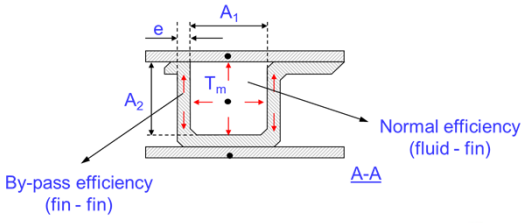
- **Model is based on:**
  - Conservation laws for mass, momentum and energy
  - Heat is transferred between adjacent passages:
    - through the separating plates
    - by conduction through the fins

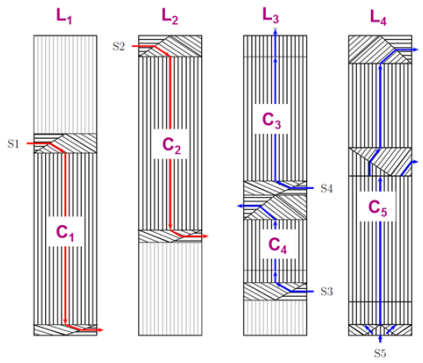






What is CO-ProSec?
A very detailed and accurate model

- **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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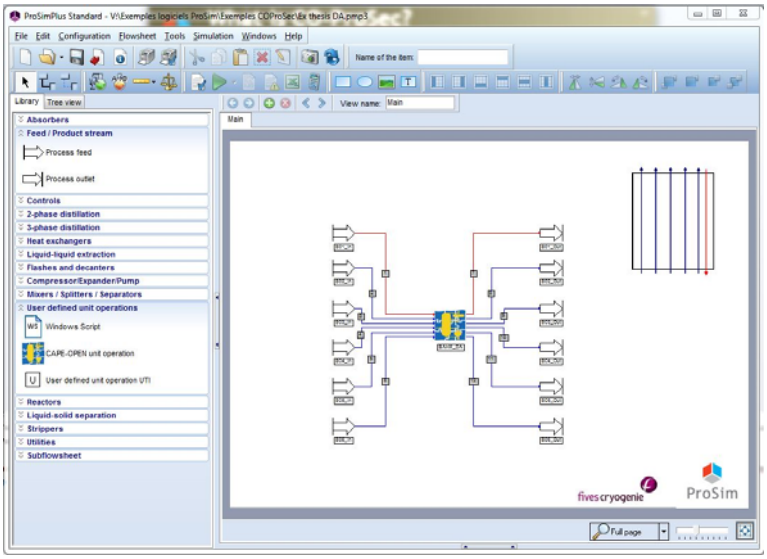

ProSim

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

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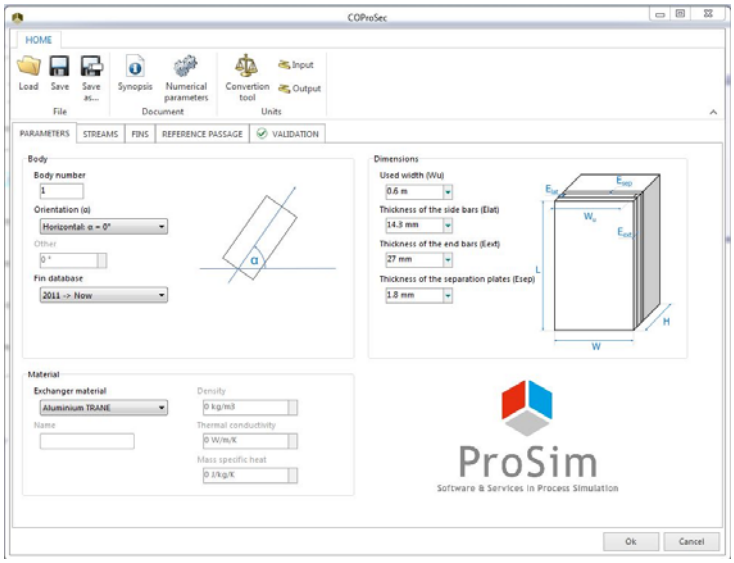

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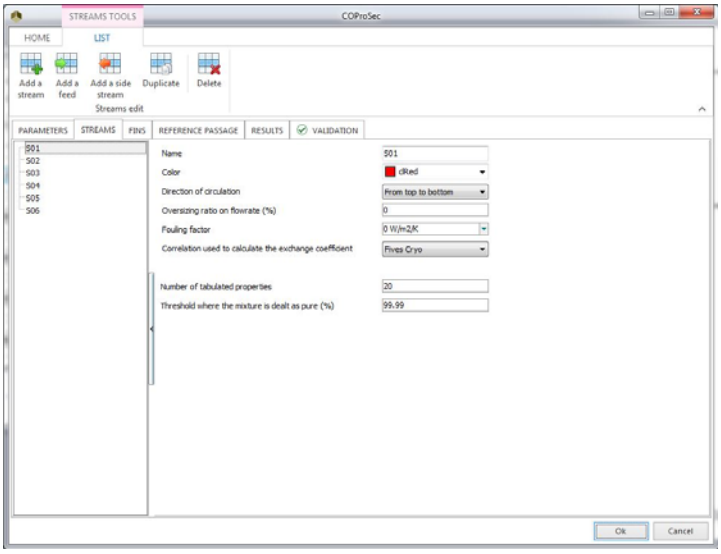
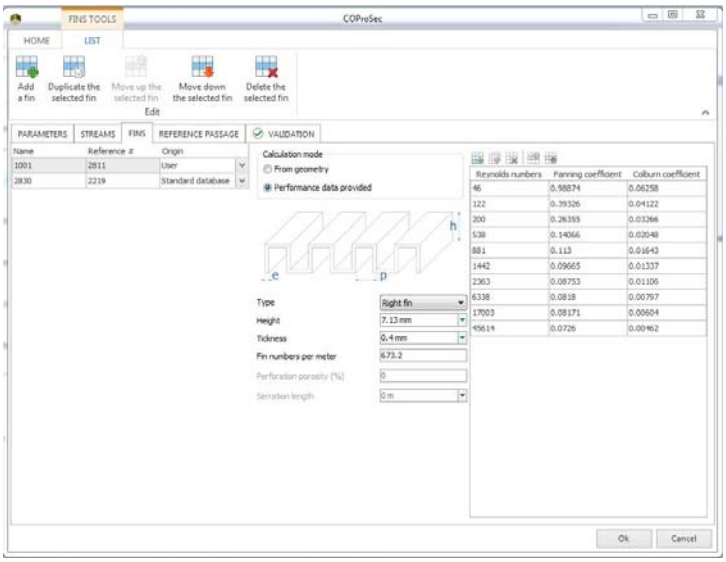
What is CO-ProSec?
An application example (Averous, 2000)



ProSim

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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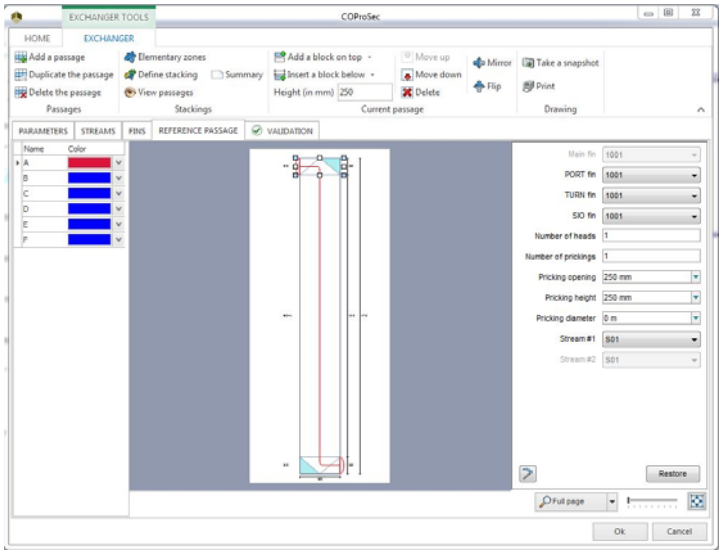

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What is CO-ProSec?
An application example (Averous, 2000)

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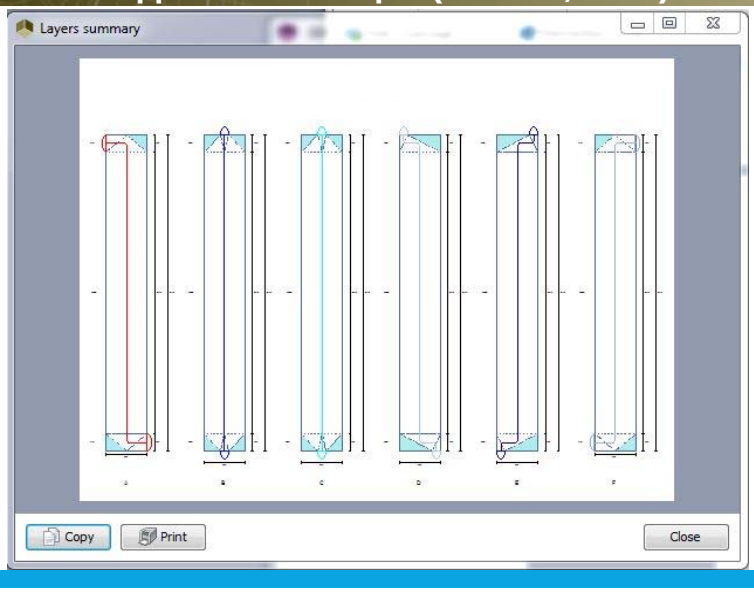

ProSim

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

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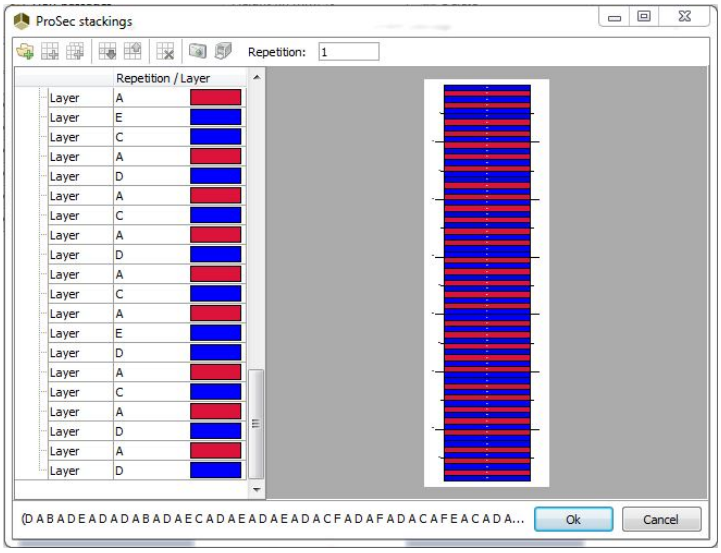

ProSim

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

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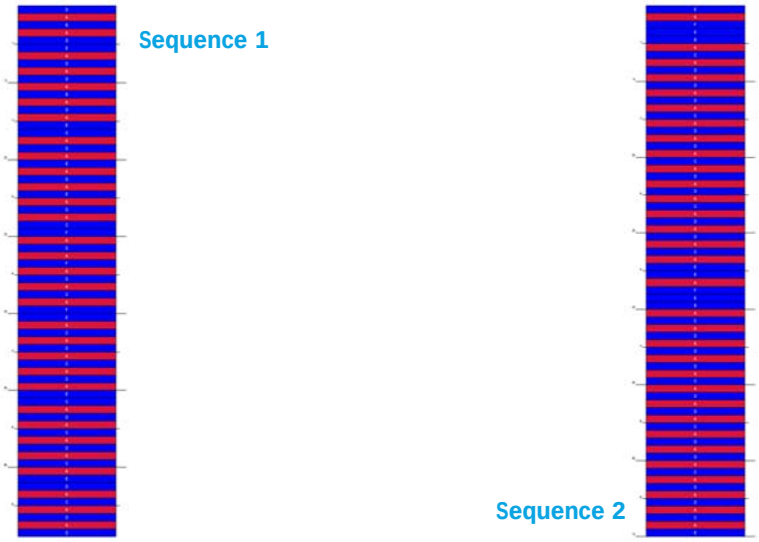

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What is CO-ProSec?
An application example (Averous, 2000)

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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

	Output temperatures (°C)			Differences (°C)	
Stream	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

	Output temperatures (°C)			Differences (°C)	
Stream	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

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

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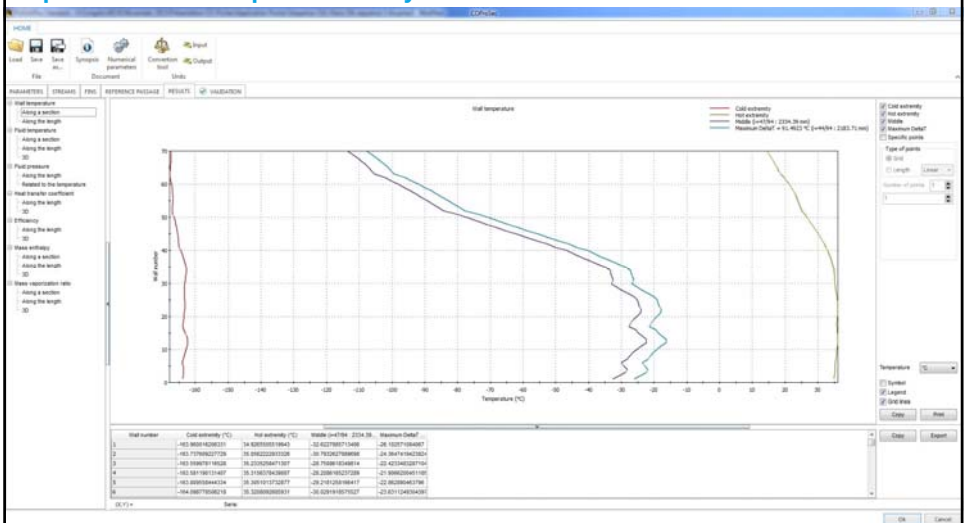
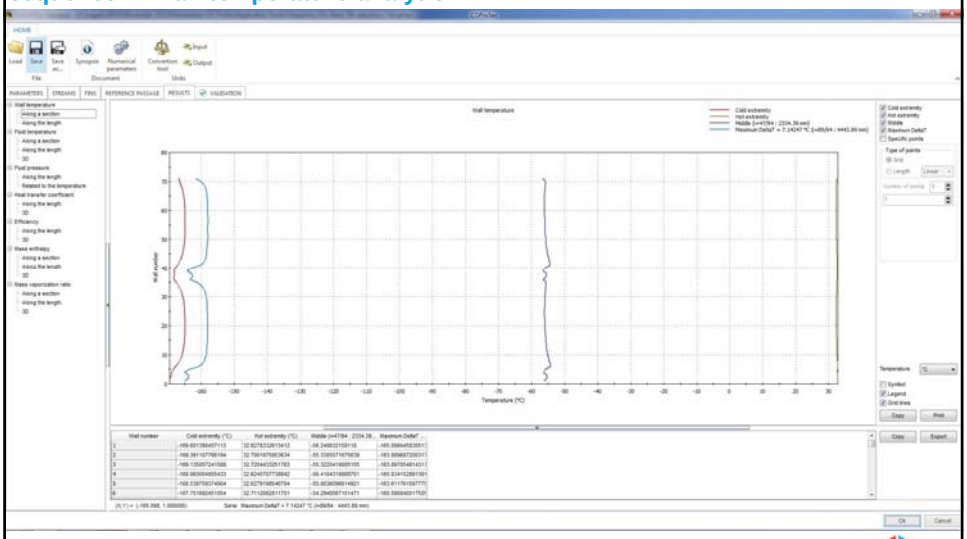
Sequence 1: wall temperature analysis



What is CO-ProSec?

An application example (Averous, 2000)

Sequence 2: wall temperature analysis



Thank you for your attention!

... any question?

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Process Engineering Studies and Software

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