



Beyond Compliance

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Assuring CAPE-OPEN Adoption

- A set of standardized interfaces are in place and have been implemented by multiple vendors
- Widespread adoption/use of these interfaces will depend upon more than technical feasibility and availability



Adoption Issues

- Quality of implementation in Process Modeling Environment (PME)
- PME interface capabilities
- Interface experience

Ideally user should not even notice that CAPE-OPEN interfaces are being used.



Implementation Quality

- Implementation should be as seamless as possible
 - Maximize existing knowledge of PME
- Exploit capabilities of PME



Implementation Quality (HTRI)

- Implemented Unit Operation interface for three most used *Xchanger Suite* modules
 - Xist (Shell and Tube)
 - Xace (Air-coolers/Economizers)
 - Xphe (Plate and frame)
- Implemented Thermodynamic interface within *Xchanger Suite*
- Tested against multiple process simulators and property packages



Implementation Quality (HTRI)

- *Xchanger Suite* calculation modules evolved as stand alone engines
 - Optimized for rigor instead of calculation speed
 - Fluid property handling modified
 - Known versus unknown duty
 - Significant input/runtime problems result in diagnostic messages and end of calculations
 - Process condition handling not consistent with most process simulators
 - HTRI based on property grid
 - Simulators provide temperature and vapor fraction which may be inconsistent with interpolated conditions



Property Options

Property Generation

Generate new properties during run

Number of pressure sets Temperature increment method

Number of temperature points Flash type

Adjust calculated points

Insert bubble point if in temperature range

Insert dew point if in temperature range

Generate component fractions

Supercritical Conditions

Critical pressure psia

Supercritical phase

Starting Temperature

Use inlet temperature

Use temperature F

Starting Pressure

Use inlet pressure

Use pressure psia

Ending Temperature

Use opposite stream inlet temperature

Use calculated outlet temperature

Temperature estimate F

Use temperature F

Ending Pressure

Use calculated pressure

Pres. drop estimate psi

Use pressure psia

Use pressure drop psi



PME Capabilities

- Reporting
- Unit operation interface



Reporting (Native)

17	PARAMETERS					
18						
19	Exchanger Design (End Point)					
20						
21	Tube Side DeltaP:	0.6895 kPa *	Shell Side DeltaP:	68.95 kPa *	Passes:	---
22	UA:	845.7 kJ/C-h	Tolerance:	1.0000e-04 *		
23	Tube Side Data			Shell Side Data		
24	Heat Transfer Coefficient	---	Heat Transfer Coefficient	---		
25	Tube Pressure Drop	0.69 kPa *	Shell Pressure Drop	68.95 kPa *		
26	Fouling	0.00000 C-h-m2/kJ *	Fouling	0.00000 C-h-m2/kJ *		
27	Tube Length	1.00 m *	Shell Passes	1		
28	Tube O.D.	20.00 mm *	Shell Series	1 *		
29	Tube Thickness	2.0000 mm	Shell Parallel	1 *		
30	Tube Pitch	50.0000 mm *	Baffle Type	Single		
31	Orientation	Horizontal	Baffle Cut(%Area)	20.00 *		
32	Passes Per Shell	1 *	Baffle Orientation	Horizontal		
33	Tubes Per Shell	80 *	Spacing	800.0000 mm *		
34	Layout Angle	Triangular (30 degrees)	Diameter	530.0259 mm *		
35	TEMA Type	A E L	Area	5.03 m2		
36	SPECS					
37						
38		Specified Value	Current Value	Relative Error	Active	Estimate
39	Heat Balance	0.0000 kJ/h	1.279e-010 kJ/h	-3.553e-014	On	On
40	UA	---	845.7 kJ/C-h	---	On	On
41	Detailed Specifications					
42						
43	Heat Balance					
44	Type: Duty	Pass: Error		Spec Value: 0.0000 kJ/h		
45	UA					
46	Type: UA	Pass: Overall		Spec Value: ---		



Reporting (CAPE-OPEN)

CO-100

General properties

Unit Type: HtriCO100.Xist

Unit Name: CO-100

Unit description: CAPE-OPEN (1-0-0) for HTRI's Xist shell and tube heat exchanger program

Report to be integrated in the HYSYS Report: Output Summary

Report result from LAST unit execution

Performance	
Overdesign, %	6.120e-2
Overall U, W/m2-K	158.77
Required U, W/m2-K	158.67
Duty, MegaWatts	5.4213
Shellside h, W/m2-K	611.46
Tubeside h, W/m2-K	231.44
Shellside delta P, kPa	15.840

Material Connections | Unit Variables | **General** | Thermo

Solved | Show Unit GUI



Reporting

1	Honeywell HONEYWELL Calgary, Alberta CANADA	Case Name:	E:\Cape-Open\Samples\Sample Xist CO Case.hsc
2		Unit Set:	SI
3		Date/Time:	Sunday Feb 12 2006, 10:16:07
4			
5	CAPE-OPEN Unit 1.0 Operations: CO-100		
6	(No Datasheets exist for this unit operation)		
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

Can CAPE-OPEN access the native reporting mechanisms?



Unit Operation Interface

- Access allowed to native unit operation interface
 - Required for complete control of unit operation
- Allows population of parameters in PME
 - Necessary for PME access to unit operation parameters



Unit Operation Interface (CAPE-OPEN)

CO-100

Unit Specific Data and Public Variables

Name	Type	Mode	Lower bound	Upper bound	Value	Value
Input shell inside diameter, m	Real	IN	0	1E+35	1	1
Input duty, J/s	Real	IN	0	1E+35	0	0
Shell inside diameter, m	Real	OUT	0	1E+35	0.99999994136982	
Baffle spacing, m	Real	OUT	0	1E+35	1.399999991081953	
Tube passes	Real	OUT	0	1E+35	1	
Tube diameter, m	Real	OUT	0	1E+35	001014746726E-02	
Tube pitch ratio	Real	OUT	0	1E+35	1.24999889731631	
Tube length, m	Real	OUT	0	1E+35	6.09592616729736	
Tube wall thickness, m	Real	OUT	0	1E+35	999955956265E-04	
Shellside pressure drop, Pa	Real	OUT	0	1E+35	15843.1952070794	
Tubeside pressure drop, Pa	Real	OUT	0	1E+35	1693.93267464606	
Shellside coefficient, J/m2-K	Real	OUT	0	1E+35	611.393741699219	
Tubeside coefficient, J/m2-K	Real	OUT	0	1E+35	231.445079202271	
Area, m2	Real	OUT	0	1E+35	355.874785226074	
U, J/m2-K	Real	OUT	0	1E+35	158.763096513367	
EMTD, K	Real	OUT	0	1E+35	96.0103344901794	
...

Reset Parameters

Material Connections | **Unit Variables** | General | Thermo

Solved

Show Unit GUI



Unit Operation Interface (Native) HTR

L/R Exch

Rating

Sizing

Parameters

Sizing Data

Overall Shell Tube Accept any input data

Configuration

Number of Shell Passes	1
Number of Shells in Series	1
Number of Shells in Parallel	1
Tube Passes per Shell	1
Exchanger Orientation	Horizontal
First Tube Pass Flow Direction	Counter
Elevation (Base)	0.0000

TEMA Type

Calculated Information

Shell HT Coeff [kJ/h-m ² -C]	<empty>
Tube HT Coeff [kJ/h-m ² -C]	<empty>
Overall U [kJ/h-m ² -C]	168.2
Overall UA [kJ/C-h]	845.7
Shell DP [kPa]	68.95
Tube DP [kPa]	0.6895
Heat Trans. Area per Shell [m ²]	5.027
Tube Volume per Shell [m ³]	1.608e-002
Shell Volume per Shell [m ³]	0.1955

Design **Rating** Worksheet Performance Dynamics HTFS - TASC

Delete Update Ignored



Unit Operation Interface (Extension)

Heat Exchanger Model

Heat Leak/Loss

None Extremes Proportional

Delta P 68.95 kPa

UA 845.7 kJ/C-h

Shell Side

Exchanger Geometry

Calculate Ft Factor

Tube Passes per Shell	Shell Passes	Shells In Series	First Pass	Shell TEMA Type
1	1	1	Counter	E

Design Rating Worksheet Performance Dynamics HTFS - TASC

Delete OK Update Ignored

Can CAPE-OPEN allow access to native unit operation interface?



Interface Experience

- Unit Operation interface tested against HYSYS, ASPEN Plus, PRO/II, and UniSim Design
- Property package interface tested against ASPEN Plus, PPDS, Simulis, and UniSim Design



Interface Experience

- Successful interface with one software package does not guarantee it will work with other packages
- Interface required modification for each new package tested
- Requires software packages to be available for testing and interaction between companies

Overall experience was successful in that common code used for all packages!



Interface Experience

- Most problems have been related to properties
- For example overall enthalpy:
 - Software A: Calculated automatically via CalcFlash
 - Software B: Must be specified in the CalcFlash property list
 - Software C: Due to a bug CalcFlash throws an exception when property list supplied
 - Software D: Not calculated by CalcFlash, must be determined from phase properties
- Makes code more complex than necessary



Interface Experience

- Examples of some other problems
 - Volume property calculated instead of Density. Modified HTRI software to detect this and use the available property.
 - IDispatch Invoke method not supported. Modified HTRI software to never use Invoke.
 - IPersistStorage interface not supported. Other vendors implemented IPersistStorage.



Interface Experience

- Improved documentation
 - Flexibility interferes with standardization. Allowing both Volume or Density makes things more difficult not less
 - More specific mechanisms (e.g., overall enthalpy)
 - Required/recommended properties
- Better testing software



Testing Software

- Vendors could supply
 - Program specific testers
 - Allows testing of compatibility with particular software without requiring access to vendor software
 - Could be available to CAPE-OPEN members on website
 - Sample code
 - Provides additional examples beyond Mixer/Splitter block
 - Jump start for new members
- CAPE-OPEN could supply
 - Reference implementation
 - Would require multi-vendor support
 - Substantial amount of work



Summary and Conclusions

- Simply providing technically correct interfaces is not sufficient
- Vendors should optimize software for use in PME
- Additional work in PME could enhance adoption
- CAPE-OPEN could enhance documentation in some areas
 - Details of physical property handling
- Vendor specific testing tools/example code would be useful