ThermoFluidProperties

Library for Calculating Operation Characteristics of Heat Exchangers from VDI Heat Atlas

LibHeatEx

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Property Functions

Functions

Functional Dependence	Function Name	Call as Function from LibHeatEx DLL	Function
$\Phi_A = f\left(ITYPE, \frac{k \cdot A}{\dot{C}_A}, \frac{\dot{C}_A}{\dot{C}_B}, NSPEC\right)$	Phi_HeatEx	PHI_HeatEx(ITYPE, kaCA, CACB, NSPEC)	Dimensionless temperature changes
$\frac{k \cdot A}{\dot{C}_A} = f\left(ITYPE, \Phi_A, \frac{\dot{C}_A}{\dot{C}_B}, NSPEC\right)$	kaCA_HeatEx	kaCA_HeatEx (ITYPE, PHI, CACB, NSPEC)	Number of transfer units
$\frac{\dot{C}_A}{\dot{C}_B} = f\left(ITYPE, \Phi_A, \frac{k \cdot A}{\dot{C}_A}, NSPEC\right)$	CACB_HeatEx	CACB_HeatEx (ITYPE, PHI, kaCA, NSPEC)	Heat capacity rate ratios

Units: All quantities are dimensionless.

Equations: :

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Dimensionless temperature changes	$\Phi = Phi = \frac{t_{H1} - t_{H2}}{t_{H1} - t_{K1}}$	**Determination:**
		A – heating surface
	$\Phi_A = \Phi_B \cdot \frac{\dot{C}_B}{\dot{C}_A}$ $\quad \Phi_B = \Phi_A \cdot \frac{\dot{C}_A}{\dot{C}_B}$	c_p – heat capacity
		k - heat transfer coefficient
Number of transfer units	$\frac{k \cdot A}{\dot{C}_A} = \frac{\Delta \vartheta_A}{\Delta \vartheta_{AB}^m} = \frac{k \cdot A}{\dot{C}_B} \cdot \frac{\dot{C}_B}{\dot{C}_A}$	Indexing:
		A – flow A B – flow B
	$\frac{k \cdot A}{\dot{C}_B} = \frac{\Delta \vartheta_B}{\Delta \vartheta_{AB}^m} = \frac{k \cdot A}{\dot{C}_A} \cdot \frac{\dot{C}_A}{\dot{C}_B}$	H – heating medium K – cooling medium
Ratios of the heat capacity rate	$\frac{\dot{C}_A}{\dot{C}_B} = \frac{\Delta \vartheta_B}{\Delta \vartheta_A}$ $\quad \frac{\dot{C}_B}{\dot{C}_A} = \frac{\Delta \vartheta_A}{\Delta \vartheta_B}$	1 – inlet of A and B 2 – outlet of A and B
$\dot{C}_A$ - heat capacity rate flow A	$\dot{C}_A = \dot{m}_A \cdot c_{pA}$	$\dot{m}$ - mass flow
		c_p – isobaric heat capacity
$\dot{C}_B$ - heat capacity rate flow B	$\dot{C}_B = \dot{m}_B \cdot c_{pB}$	
Δt_A - temperature changes flow A	$\Delta t_A = t_{A1} - t_{A2}$	
Δt_B - temperature changes flow B	$\Delta t_B = t_{B1} - t_{B2}$	
c_{pA}^m - mean isobaric heat capacity of flow A	$c_{pA}^m = \frac{h_{A2} - h_{A1}}{t_{A2} - t_{A1}}$ for $p_A \approx const.$ approximation: $c_{pA}^m \approx \frac{1}{2}\left[c_{pA}(t_{A1}) + c_{pA}(t_{A2})\right]$	h – specific enthalpy t – temperature p – pressure of flow A and flow B

$c_{p\mathrm{B}}^{\mathrm{m}}$ - mean isobaric heat capacity of flow B	$c_{p\mathrm{B}}^{\mathrm{m}} = \dfrac{h_{\mathrm{B2}} - h_{\mathrm{B1}}}{t_{\mathrm{B2}} - t_{\mathrm{B1}}}$ for $p_{\mathrm{B}} \approx const.$ approximation: $c_{p\mathrm{B}}^{\mathrm{m}} \approx \dfrac{1}{2}\left[c_{p\mathrm{B}}\left(t_{\mathrm{B1}}\right) + c_{p\mathrm{B}}\left(t_{\mathrm{B2}}\right)\right]$

Range of Validity

The LibHeatEx property library has been developed to calculate different heat exchangers, which have been taken from the VDI-Heat Atlas [3].

One of the two streams is referred to as heating medium and the other one as cooling medium. The heating medium transfers thermal energy to the cooling medium.

Thermal losses to the surrounding are neglected, which means that the heat exchanger is calculated adiabatically. The result of the first law of thermodynamics are functional coherences between the dimensionless temperature changes *Phi*, the number of transfer units $\frac{k \cdot A}{\dot{C}_{\mathrm{A}}}$, which is also referred to as *NTU* or *N,* and the ratios of the heat capacity rate $\frac{\dot{C}_{\mathrm{A}}}{\dot{C}_{\mathrm{B}}}$ or *R*. The basic functional dependency is $\Phi = Phi = \mathrm{f}\left(\frac{k \cdot A}{\dot{C}_{\mathrm{A}}}, \frac{\dot{C}_{\mathrm{A}}}{\dot{C}_{\mathrm{B}}}\right)$. In most cases the equation cannot be solved for the other two variables. These functions are $\frac{k \cdot A}{\dot{C}_{\mathrm{A}}} = \mathrm{f}\left(\Phi, \frac{\dot{C}_{\mathrm{A}}}{\dot{C}_{\mathrm{B}}}\right)$ and $\frac{\dot{C}_{\mathrm{A}}}{\dot{C}_{\mathrm{B}}} = \mathrm{f}\left(\Phi, \frac{k \cdot A}{\dot{C}_{\mathrm{A}}}\right)$, they therefore have to be calculated iteratively. In order to select the correct type of the heat exchanger, please use Table 1 of this User's Guide or the help file LibHeatEx.hlp. Each heat exchanger type is assigned to one number, which is specified as the variable I_{TYPE}. This is also the first input parameter for each function in Excel®.

There are also functions with a variable number of tube rows or passes which is indicated by the parameter N_{SPEC}. N_{SPEC} is also given in Table 1 and in the help file LibHeatEx.hlp.

The functional dependencies of flow A with I_{TYPE} and N_{SPEC} are

$$\Phi_{\mathrm{A}} = \mathrm{f}\left(ITYPE, \frac{k \cdot A}{\dot{C}_{\mathrm{A}}}, \frac{\dot{C}_{\mathrm{A}}}{\dot{C}_{\mathrm{B}}}, NSPEC\right),$$

$$\frac{k \cdot A}{\dot{C}_{\mathrm{A}}} = \mathrm{f}\left(ITYPE, \Phi_{\mathrm{A}}, \frac{\dot{C}_{\mathrm{A}}}{\dot{C}_{\mathrm{B}}}, NSPEC\right), \text{ and}$$

$$\frac{\dot{C}_{\mathrm{A}}}{\dot{C}_{\mathrm{B}}} = \mathrm{f}\left(ITYPE, \Phi_{\mathrm{A}}, \frac{k \cdot A}{\dot{C}_{\mathrm{A}}}, NSPEC\right).$$

The dependencies for flow B are

$$\Phi_\mathrm{B} = \mathrm{f}\left(ITYPE, \frac{k \cdot A}{\dot{C}_\mathrm{B}}, \frac{\dot{C}_\mathrm{B}}{\dot{C}_\mathrm{A}}, NSPEC \right),$$

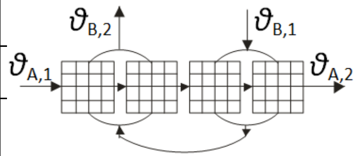
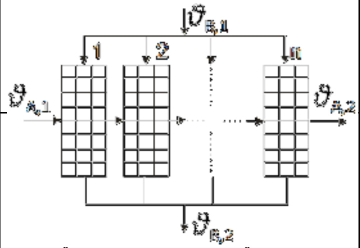
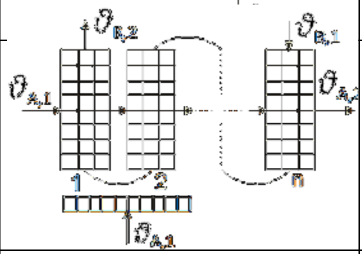
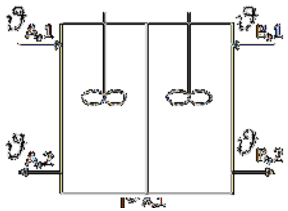
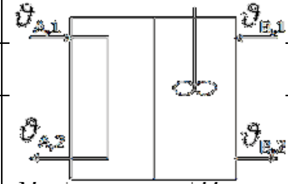
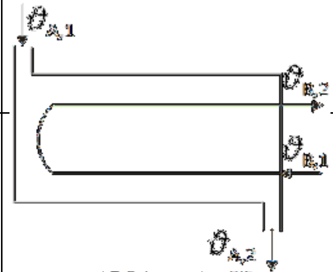
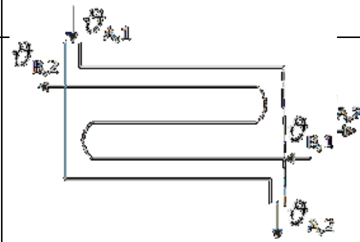
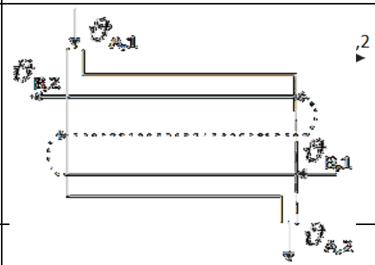
$$\frac{k \cdot A}{\dot{C}_\mathrm{B}} = \mathrm{f}\left(ITYPE, \Phi_\mathrm{B}, \frac{\dot{C}_\mathrm{B}}{\dot{C}_\mathrm{A}}, NSPEC \right), \text{ and}$$

$$\frac{\dot{C}_\mathrm{B}}{\dot{C}_\mathrm{A}} = \mathrm{f}\left(ITYPE, \Phi_\mathrm{B}, \frac{k \cdot A}{\dot{C}_\mathrm{B}}, NSPEC \right).$$

The range of validity for the different parameters are shown in the following Table 1

Table 1: Range of validity

Quantities	**Range of validity**
Dimensionless temperature changes:	0 ≤ *Phi* ≤ 1
Number of transfer units:	0 < *kaCA*
Heat capacity rate ratios:	0 ≤ *CACB*
Type of Heat Exchanger:	0 < *ITYPE* ≤ 24
Number of tube rows or passes:	0 = *NSPEC* for ITYPE 1-9; 12-19; 21-24 0 < *NSPEC* for ITYPE 10; 11; 20

I_{TYPE}	Type	Flow arrangement	N_{SPEC}
9	Counterdirected countercurrent cross-flow with four tube rows and two passes		0
10	Cross-flow with *n* tube rows and one pass n = 1,2,…, ∞		1,2..∞
11	Codirected countercurrent cross-flow with *n* tube rows and *n* passes n = 1,2,…, ∞		1,2..∞
12	Two-sided stirred tank		0
13	One-sided stirred tank		0
14	One shell-side and two tube-side passes		0
15	One shell-side and three tubeside passes, two countercurrent		0
16	One shell-side and two tubeside passes, both countercurrent		1,2..∞

I_{TYPE}	Type	Flow arrangement	N_{SPEC}
1	Pure counter current flow i = A,B		0
2	Pure cocurrent flow i = A,B		0
3	Pure cross-flow i = A,B		0
4	Cross-flow with one tube row, laterally mixed on one side i = A,B		0
5	Cross-flow, laterally mixed on both sides i = A,B		0
6	Counterdirected countercurrent cross-flow with two tube rows and two passes		0
7	Counterdirected countercurrent cross-flow with three tube rows and three passes		0
8	Counterdirected countercurrent cross-flow with four tube rows and four passes		0

Table 2: List of heat exchanger types