Heat exchanger flow types

For example, air is to be cooled from 38°C to 16°C with water from 6°C to 12°C.

With the software AHH (see application TEM) one can make a rudimentary estimate of the performance depending on the type of flow, which, however, is only valid for dry air than for a purely sensitive cooling process.

If a heat exchanger could be built in such a way, that there was pure counterflow, the mean logarithmic temperature difference (Δtm) would be 16,745K.

With pure direct co-current flow, the Δtm would be reduced to 13,465K, which would correspond to a reduction to 80,413%. Accordingly, you would have to accept a performance loss of 19,587% with the same size of the heat exchanger.

This would also answer the question of the loss of performance, if the heat exchanger had been connected incorrectly with regard to the cold water.

Assuming the heat exchanger had 6 rows of tubes, this would correspond to 3 cross-counterflow packages, reducing the Δtm to 16.613K, which would correspond to a reduction to 99.211%. With the same size of the heat exchanger, you would only have to accept a performance loss of only 0.789%, i.e. practically nothing.

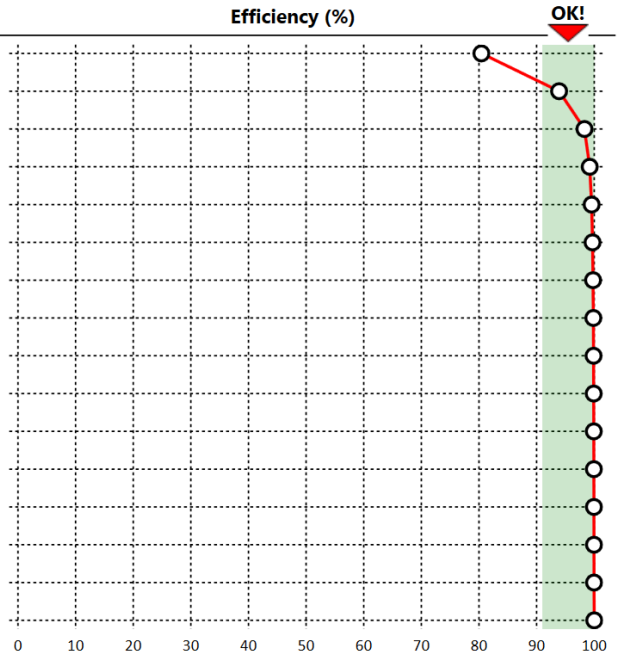
Example

Countercurrent flow in laminated heat exchangers?

Hot inlet	°C	38.000
Hot outlet	°C	16.000
Cold inlet	°C	6.000
Cold outlet	°C	12.000
Counter-current flow	K	**16.745**
Counter-current flow	%	**100.000**

Counter-current flow in laminated heat exchangers only exists in the imagination of some producers who do not care whether the temperature efficiency of heat recovery systems is only 50 % instead of the promised 70 %! One hopes that it will not be measured. The correct procedure is described below and has been confirmed by measurements in the laboratory.

Average temp. diff.	K	%	Symbol
Co-current flow	13.465	80.413	
Cross flow	15.724	93.902	
Cross-counter-current flow (2x)	16.460	98.299	
Cross-counter-current flow (3x)	16.613	99.211	
Cross-counter-current flow (4x)	16.669	99.546	
Cross-counter-current flow (5x)	16.696	99.705	
Cross-counter-current flow (6x)	16.710	99.793	
Cross-counter-current flow (7x)	16.719	99.847	
Cross-counter-current flow (8x)	16.725	99.882	
Cross-counter-current flow (9x)	16.729	99.906	
Cross-counter-current flow (10x)	16.732	99.924	
Cross-counter-current flow (11x)	16.734	99.937	
Cross-counter-current flow (12x)	16.736	99.947	
Cross-counter-current flow (13x)	16.738	99.958	
Cross-counter-current flow (14x)	16.739	99.966	
Counter-current flow	**16.745**	**100.000**	



Example: Heater in CC-System

Countercurrent flow in laminated heat exchangers?

But what if the air at the inlet has a relative humidity of 40%, for example, and a high latent power share occurs as a result of condensation of water? The HEH software or the HES software, for example, can provide information about this, see following pages.

Correct water connections (cross-counter flow), capacity 261,765 kW.
Wrong water connections (cross-co-current flow), capacity 229,073 kW.

Cooler: 40/35/15-6R-36T-1953A-2.9PA-36C-Cu/Al/AISI 304 — **Software by www.zcs.ch**

Capacity	kW	261.765	------ sensible:	149.525
Surface reserve	%	0.000	latent:	112.240
Present surface	m2	371.717	frost:	0.000
Required surface	m2	371.716		
k-coeff.	W/m2K	43.989		
Average temp. diff. (95.60 %)	K	16.009		

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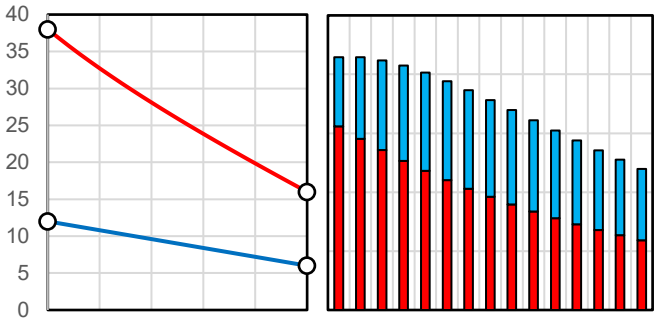
Plant
Object
Position

Air humid (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	38.000	16.000	20.000
Rel. humidity	%	40.000	88.732	40.000
Abs. humidity	g/kg	16.638	10.049	5.783
Density humid	kg/m3	1.123	1.213	1.200
Enthalpy humid	kJ/kg	81.028	41.525	34.801
Volume flow humid	m3/h	21595.026	19861.165	20000.000
Mass flow dry	kg/h	23855.617	23855.617	23855.617
Condensate flow	kg/h		157.185	
Surface temperature	°C	18.989	8.852	
Velocity	m/s	2.133	1.962	1.975
Pressure drop (dry 58 Pa)	Pa		69.378	

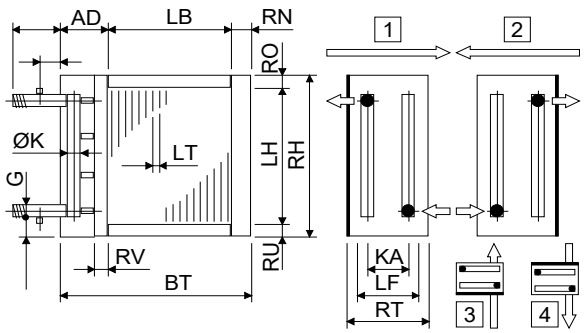
Water (ff = 0.00005 m2K/W)		
Temp. Inlet	°C	6.000
Temp. Outlet	°C	12.000
Temp. Selection	°C	8.190
Density	kg/m3	999.850
Spec. heat	kJ/kgK	4.196
Heat cond.	W/mK	0.577
Viscosity	Pas	1.378E-03
Volume flow	m3/h	37.437
Velocity	m/s	1.725
Reynolds	---	18281.536
Pressure drop (T/C = 7.426)	kPa	47.014

Temp. (°C)



Technical data

Tubes total		Piece	216	Tubes:		Cu
Tubes blank		Piece	0	Tubes:		smooth
Int. vent./drains		Piece	0	Tubes:		staggered
Tube rows on the depth		Piece	6	Tubes:		circular
Tube rows on the height		Piece	36	Collectors:	1.25 m/s	Cu
Tube coupling in series		Piece	6	Connections:	1.25 m/s	Rg7
Number of circuits (NC)		Piece	36	Fins:		Al
Volume		l	101	Fins:		ribbed
Weight		kg	242	Circulations:	1	Default
Connections	G	---	4"	Frame:	2.0 mm	AISI 304
Frame height	RH	mm	1500	Protection:		without
Frame width	BT	mm	2200	Protection:		---
Frame depth	RT	mm	310	Air flow direction:		horizontal
Finned height	LH	mm	1440			
Finned width	LB	mm	1953			
Finned depth	LF	mm	210			
Frame on top	RO	mm	30			
Frame on bottom	RU	mm	30			
Frame in front	RV	mm	30			
Frame on back (~65mm)	RN	mm	53			
Collector-Diameter	K	mm	108			
Collector covering	AD	mm	194			
Collector distance	KA	mm	175			
Fin spacing	LT	mm	2.915			
Fin thickness	LD	mm	0.200			
Tube diameter	DA	mm	15.400	Delivery:		5-6 weeks
Tube diameter	da	mm	15.400	Validity:		12 weeks
Tube thickness	S	mm	0.400	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	40.000	Payment:		30 days net
Tube interval on the depth	S2	mm	35.000	**Price net:**	**EUR**	**4073.00**



Cooler: 40/35/15-6R-36T-1953A-2.9PA-36C-Cu/Al/AISI 304 — **Software by www.zcs.ch**

Capacity	kW	229.073	------ sensible:	136.677
Surface reserve	%	0.000	latent:	92.396
Present surface	m2	371.717	frost:	0.000
Required surface	m2	371.717		
k-coeff.	W/m2K	40.902		
Average temp. diff. (83.41 %)	K	15.067		

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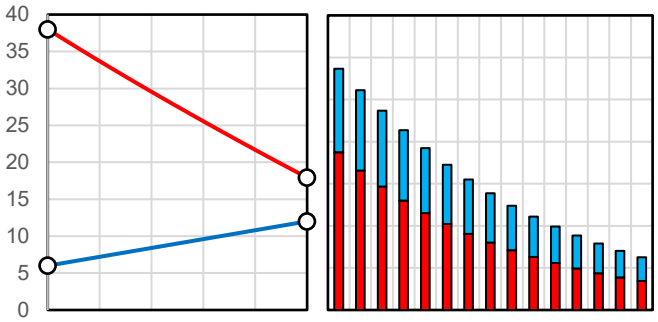
Plant
Object
Position

Air humid (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	38.000	17.933	20.000
Rel. humidity	%	40.000	87.465	40.000
Abs. humidity	g/kg	16.638	11.214	5.783
Density humid	kg/m3	1.123	1.204	1.200
Enthalpy humid	kJ/kg	81.028	46.459	34.801
Volume flow humid	m3/h	21595.026	20030.808	20000.000
Mass flow dry	kg/h	23855.617	23855.617	23855.617
Condensate flow	kg/h		129.395	
Surface temperature	°C	17.057	13.772	
Velocity	m/s	2.133	1.978	1.975
Pressure drop (dry 57 Pa)	Pa		67.244	

Water (ff = 0.00005 m2K/W)		
Temp. Inlet	°C	6.000
Temp. Outlet	°C	12.000
Temp. Selection	°C	8.190
Density	kg/m3	999.850
Spec. heat	kJ/kgK	4.196
Heat cond.	W/mK	0.577
Viscosity	Pas	1.378E-03
Volume flow	m3/h	32.762
Velocity	m/s	1.510
Reynolds	---	15998.364
Pressure drop (T/C = 7.589)	kPa	36.868

Temp. (°C)



Technical data

Tubes total		Piece	216	Tubes:		Cu
Tubes blank		Piece	0	Tubes:		smooth
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Tube rows on the depth		Piece	6	Tubes:		circular
Tube rows on the height		Piece	36	Collectors:	1.09 m/s	Cu
Tube coupling in series		Piece	6	Connections:	1.09 m/s	Rg7
Number of circuits (NC)		Piece	36	Fins:		Al
Volume		l	101	Fins:		ribbed
Weight		kg	242	Circulations:	1	Default
Connections	G	---	4"	Frame:	2.0 mm	AISI 304
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Collector distance	KA	mm	175			
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Fin thickness	LD	mm	0.200			
Tube diameter	DA	mm	15.400	Delivery:		5-6 weeks
Tube diameter	da	mm	15.400	Validity:		12 weeks
Tube thickness	S	mm	0.400	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	40.000	Payment:		30 days net
Tube interval on the depth	S2	mm	35.000	**Price net:**	**EUR**	**4073.00**