Type:								
Heat exchanger:	Tube coil heat exchanger without displacement cylinder							
Flow pattern:								
	Inside coil				**Around coil**			
Medium	R410A				Water			
Mass flow	m_i	**0.03354**	kg/s		m_a	*0.3*	kg/s	
Volume flow	V_i	**2.226e-4**	m³/s		V_a	**3.036e-4**	m³/s	
Inlet pressure (abs.)	p	32.89	bar		p	*1*	bar	
Inlet temperature	$\vartheta_{e,i}$	**53.1**	°C		$\vartheta_{e,a}$	***46.41***	°C	
Outlet temperature	$\vartheta_{a,i}$	**52.9**	°C		$\vartheta_{a,a}$	*50*	°C	
Mean temperature	$\vartheta_{m,i}$	53	°C		$\vartheta_{m,a}$	**48.21**	°C	
Heat duty	Q_i	-4.5	kW		Q_a	**4.5**	kW	
Heat loss					$Q_{v,a}$	0	kW	
Fouling resistance	f_i	0	m²·K/W		f_a	0	m²·K/W	
Density	ρ_i	872.7	kg/m³		ρ_a	*988.1*	kg/m³	
Specific heat capacity	cp_i	2386	J/(kg·K)		cp_a	*4180*	J/(kg·K)	
Thermal conductivity	λ_i	0.07305	W/(m·K)		λ_a	*0.6385*	W/(m·K)	
Dynamic viscosity	η_i	0.08029	mPa·s		η_a	*0.5634*	mPa·s	
For phase change								
Density vapour	ρ_{Di}	150.7	kg/m³		ρ_{Da}		kg/m³	
Heat of evaporation	Δhv	133687	J/kg		Δhv		J/kg	
Vapour mass fraction inlet	x_e	1	-		x_e		-	
Vapour mass fraction outlet	x_a	0	-		x_a		-	

Geometry:

Shell outside diameter	Do	44.6	mm	Shell wall thickness	s	3.25	mm
Shell inside diameter	Di	***38.1***	mm				
Tube outside diameter	do	*6.35*	mm	Tube wall thickness	si	0.5	mm
Tube inside diameter	di	**5.35**	mm				
Coil diameter	D_C	***30.75***	mm	Coil pitch	h	***8***	mm
Coil-shell distance		0.5	mm	Distance of windings	w	*8*	mm
Number of tubes in the coil				n_R 1 -			
Tube material				Copper			
Thermal conductivity of tube material				λ 318 W/(m·K)			

Valuation:

		Required			Final		Overdesign	
Total exchanger area	A	**0.5293**	m²	A,f	0.5	m²	**-5.534**	%
Total coil length	lc	**2190**	mm	lc,f	**2069**	mm		
Tube length per tube	lt	**26.53**	m	lt,f	**25064**	mm		
Number of windings per tube	N	**273.7**	-	N,f	***258.6***	-		
Heat transfer coefficient (inside)				α_i	**2704**	W/(m²·K)		
Heat transfer coefficient (outside)				α_a	**10108**	W/(m²·K)		
Overall heat transfer coefficient				k	**1853**	W/(m²·K)		
Logarithmic mean temperature diff. LMTD				$\Delta\vartheta_{log}$	**4.588**	K		
FN Factor (Correction factor for LMTD)				FN	**1**	-		
Total fouling resistance				f	**0**	m²·K/W		

Inside coil				**Around coil**			
Flow velocity		**9.903**	m/s	Flow velocity		**0.5765**	m/s
				Reynolds number	Re	*10050*	-
Mean tube wall temperature	ϑ_{wi}	**49.1**	°C	Mean tube wall temperature	ϑ_{wa}	***49.08***	°C
Pressure drop	Δp_i		bar	Pressure drop	Δp_a	**0.08051**	bar
				Inlet nozzle			
Connection arrangement		axial	-	Nominal width		DN 20	
tangential / radial / axial ?				Outside diameter		26.9	mm
				Inside diameter		22.3	mm
				Velocity		**0.7774**	m/s
				Outlet nozzle			
				Nominal width		DN 20	
				Outside diameter		26.9	mm
				Inside diameter		22.3	mm
				Velocity		**0.7774**	m/s

Equations

Heat balance: Inside coil

$Q_i = m_i \cdot cp_i \cdot (\vartheta_{a,i} - \vartheta_{e,i}) + m_i \cdot (x_e - x_a) \cdot \Delta hv_i =$

0.03354 kg/s · 2386 J/(kg·K) · $(\vartheta_{a,i} - \vartheta_{e,i})$ + 0.03354 kg/s · (1−0) · 133687 J/kg = -4500 W

Heat balance: Around coil

$Q_a = m_a \cdot cp_a \cdot (\vartheta_{a,a} - \vartheta_{e,a}) = m_a \cdot$ 4180 J/(kg·K) · (50°C − 46.41°C) = 4500 W

Heat balance:

$Q_i = -(Q_a - Q_v) = -(4500\ W - 0\ W) = -4500\ W$

Overall heat transfer coefficient

k = **1853** W/(m²·K)

$$\frac{1}{k} = \left[\frac{1}{\alpha_i} + f_i\right] \cdot \frac{da}{di} + \frac{da \cdot ln\left(\frac{da}{di}\right)}{2 \cdot \lambda} + \frac{1}{\alpha_a} + f_a \Leftrightarrow$$

$$\frac{1}{1853\ W/(m^2 \cdot K)} = \left[\frac{1}{2704\ W/(m^2 \cdot K)} + 0\ m^2 \cdot K/W\right] \cdot \frac{0.00635\ m}{0.00535\ m} + \frac{0.00635\ m \cdot ln\left(\frac{0.00635\ m}{0.00535\ m}\right)}{2 \cdot 318\ W/(m \cdot K)} + \frac{1}{10108\ W/(m^2 \cdot K)} + 0\ m^2 \cdot K/W$$

$Q = k \cdot A \cdot \Delta\vartheta_{log} \cdot FN = 1853\ W/(m^2 \cdot K) \cdot 0.5293\ m^2 \cdot 4.588\ K \cdot 1 = -4500\ W$