Thermomechanics

i Calculation without errors.

ii Project information

? Calculations section

1.0 Calculation units, units conversion

1.1 Calculation units: SI Units (N, mm, kW...)

1.2 Units conversion

Length	1	m	39.37007874	inch
Area	1	m^2	10.76391042	$feet^2$
Volume	1	m^3	35.31466672	$feet^3$
Density	1	kg/m^3	0.062427961	lb/ft^3
Mass	1	kg	2.204624	lb
Kin.viscosity	1	cSt	0.038750678	ft^2/h
Dyn.viscosity	1	Poise	0.002088555	Slug/(ft·s)
Temperature	20	°C	68	°F
Flow rate	1	m^3/s	1	m^3/s

Speed	1	m/s	3.6	km/h
Acceleration	1	m/s^2	3.280839895	ft/s^2
Revolutions	1	/s	6.283185307	rad/sec
Force	1	N	0.224809	lbf
Moment	1	Nm	0.737561	lbf·ft
Pressure	1	Atm	14.22321814	psi
Power	1	W	3.41442595	Btu/h
Energy	1	kWh	3412.12407	BTU
Specific heat capacity	1	J/kg/°K	0.000238846	BTU/lb/°R
Thermal conductivity	1	W/m/°K	0.578175982	BTU·ft/h/ft²
Heat Transfer Coeff.	1	$W/m^2/°K$	0.176228039	$Btu/h/ft^2/°F$
Heat Flux Density	1	W/m^2	0.317210472	$BTU/h/ft^2$
Thermal resistance	1	$m^2.°K/W$	5.674465912	$h.ft^2.°F/Btu$
Heating value	1	J/kg	0.000429923	Btu/lb

2.0 Energy: Temperature change, phase change, fuel heating value

2.1 Energy for temperature change for various materials

2.2 Material group: 7. Liquids (L)

2.3 Material: 102-L. Water at 10°C (ρ=1000; λ=0.6; Cp=4190)

2.4 Density, Thermal conductivity	Rho, λ	1000	0.6	[kg/m³], [W/m/K]	
2.5 Specific heat capacity	Cp	4190	4190	[J/kg/K]	☑
2.6 Mass of medium	m	1		[kg]	☐
2.7 Temperature change	ΔT	10		[°C]	☐
2.8 Energy	E	0.011638898		[kWh]	☑
2.9 Energy	E	41900		[J]	

2.10 Energy for phase change for various materials

2.11 Material: 14-G. Nitrogen (N) ..... [TM = -209.9°C, TB = -195.8°C]

2.12 Density, Thermal conductivity	Rho, λ	1.25	0.02598	[kg/m³], [W/m/K]
2.13 Atomic mass, Specific heat capacity	ma, Cp	14.00686	1040	[AMU], [J/kg/K]
2.14 Melting temperature, Boiling temperature	TM, TB	-209.9	-195.8	[°C]
2.15 Specific heat capacity of melting and boiling	CpM, CpB	25.73026	199.3881	[kJ/kg]
2.16 Specific heat capacity of melting and boiling	CpM, CpB	25.73026	199.3881	[kJ/kg] ☑
2.17 Mass of medium	m	1	1	[kg] ☑
2.18 Energy	EM, EB	0.007147	0.055386	[kWh]
2.19 Energy	EM, EB	25730.26	199388.1	[J]

2.20 Heat of combustion, Fuel heating value (S-solid, L-liquid, G-gas)

2.21 Fuel selection: 18-L. Ethanol (100%) (C2H5OH) ..... [HHV = 29.7 MJ/kg]

2.22 Density	Rho	789		[kg/m³]	
2.23 Heating value (Low Heating Value)	LHV	26.7	21066.3	[MJ/kg] / [MJ/m³]	
2.24 Heat of combustion (Higher Heating Value)	HHV	29.7	29.7	+-0 %	[MJ/kg] ☑
2.25 Mass of burned fuel	m	1		[kg]	
2.26 Combustion efficiency	η	95	95 %	[%]	
2.27 Energy	E	28215000		[J]	
2.28 Energy	E	7.83750627		[kWh]	

3.0 Periodic table of elements, ideal gas state and state change, thermodynamic system

3.1 Calculation of molar mass for elements, compounds, and mixtures

3.2 Summary chemical formula: N2+O2+Ar+CO2

3.3 Elements table

ID	Element name	Symbol	Number n	At.mass Ar	Mol.mass M	Density Rho	Spec.Heat Cp	Spec.HeatM CpM	Spec.HeatB CpB	Conduct. λ	Melting TM	Boiling TB	Comp. No. i
		[~]	[~]	[~]	[g/mol]	[kg/m³]	[J/kg/K]	[kJ/kg]	[kJ/kg]	[W/m/K]	[°C]	[°C]	[~]
1	007-G. Nitrogen (N) ..... [Rho = 1.25 kg/m	N	2	14.00686	28.01371	1.25	1040	25.73026	199.3881	0.02598	-209.9	-195.8	1
2	008-G. Oxygen (O) ..... [Rho = 1.43 kg/m³	O	2	15.9994	31.9988	1.43	920	13.9124	213.1267	0.02674	-218.4	-183	2
3	018-G. Argon (Ar) ..... [Rho = 1.78 kg/m³	Ar	1	39.948	39.948	1.78	520	29.73866	161.3848	0.01772	-189.2	-185.7	3
4	006-S. Carbon (C) ..... [Rho = 2250 kg/m³	C	1	12.0106	12.0106	2250	710		29623.83	129	3367	4827	4
5	008-G. Oxygen (O) ..... [Rho = 1.43 kg/m³	O	2	15.9994	31.9988	1.43	920	13.9124	213.1267	0.02674	-218.4	-183	4
6	.....												
7	.....												
8	.....												
9	.....												
10	.....												
11	.....												
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14	.....												
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16	.....												
17	.....												
18	.....												
19	.....												
20	.....												

3.5 Mixture parameters

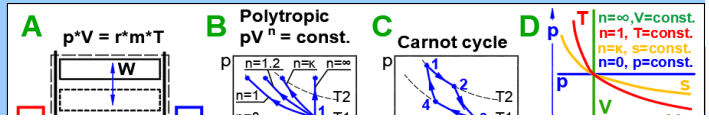
3.6 Serial number	i	1	2	3	4	5	6	7	8	9	10	11	12		
3.7 Poisson's constant	κ(i)	1.4	1.4	1.666667	1.333333									Sum	
3.8 **Molar mass**	**M(i)**	**28.0137**	**31.9988**	**39.948**	**44.0094**									**143.97**	**[g/mol]**
3.9 Mass fraction in %	x	75.518	23.135	1.288	0.059									100	[%] ☐
3.10 Molar mass	M%(i)	2.695751	0.722996	0.032242	0.001341									3.45233	[mol]

3.11 Molar mass	Msum	**28.96594581**	[g/mol]
3.12 Specific gas constant	r	**287.0426767**	[J/kg/K]
3.13 Poisson's constant	κ	**1.402849608**	[~]

3.14 Equilibrium state and ideal gas state change — 3.14b

3.15 Gas selection: 01-Air (Air) [250...1050K] ☑

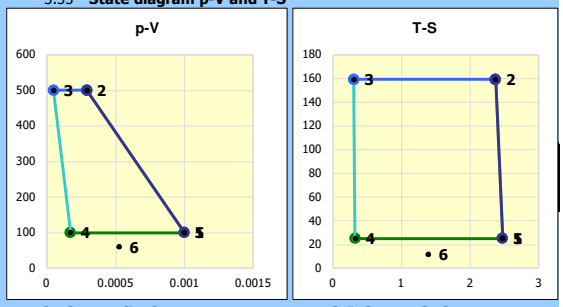
3.16 Reference temperature	Tdef	25	92.1	[°C]
3.17 Molar mass	M	28.96595	28.96595	[kg/kmol]
3.18 Specific gas constant	r	287.0427	287.0427	[J/kg/K]



3.19	Specific heat capacity (constant pressure)		cp	1006.314	1006.314	[J/kg/K]										
3.20	Specific heat capacity (constant volume)		cv	719.2713	719.2713	[J/kg/K]										
3.21	Poisson's constant		κ	1.399074	1.399074	[~]										
3.22	Amount of substance		N	1		[kmol]										
3.23	Mass		m	28.96595		[kg]										
3.24	**Ideal gas equation of state**			**Values (point 1)**					**Values (point 2)**				**Values (point 3)**			
3.25	Polytropic exponent							n	1.3	1.3	n=1.2, pV^n=c, Polytropic		1	±∞	n=1 , T=const, Isotermic	
3.26	Specific heat capacity (polytropic) / State				▼ =OK ▼			cn12	-237.5376	▼ =OK ▼	[J/kg/K]	cn23	719.2713	▼ =OK ▼	[J/kg/K]	
3.27	Mass		m1	0.001168	0.001168	[kg]		m2	0.001168	0.001168	[kg]	m3	0.000201	0.000201	[kg]	
3.28	Absolute pressure		p1	100	100	[kPa]		p2	500	500	[kPa]	p3	500	500	[kPa]	
3.29	Volume		V1	0.001	0.001	[m³]		V2	0.00029	0.00029	[m³]	V3	0.00005	0.00005	[m³]	
3.30	Temperature		T1	25	25	[°C]		T2	159.1006	159.1006	[°C]	T3	159.1006	159.1006	[°C]	
3.31	Density, amount of substance		Rho,N	1.168473	4.03E-05	[kg/m³,kmol]			4.029841	4.03E-05	[kg/m³,kmol]		4.029841	6.96E-06	[kg/m³,kmol]	
3.32	**Ideal gas equation of state**			**Values (point 4)**					**Values (point 5)**				**Values (point 6)**			
3.33	Polytropic exponent		n	1.3	1.3	n=1 , T=const, Isotermic			1	±∞	n=1 , T=const, Isotermic		1	?	n=1 , T=const, Isotermic	
3.34	Specific heat capacity (polytropic) / State		cn34	-237.5376	▼ =OK ▼	[J/kg/K]		cn45	719.2713	▼ =OK ▼	[J/kg/K]	cn56	?	▼ =OK ▼	[J/kg/K]	
3.35	Mass		m4	0.000201	0.000201	[kg]		m5	0.001168	0.001168	[kg]	m6	0.001168	0.001168	[kg]	
3.36	Volume		p4	100	100	[kPa]		p5	100	100	[kPa]	p6	100	100	[kPa]	
3.37	Volume		V4	0.000172	0.000172	[m³]		V5	0.001	0.001	[m³]	V6	0.001	0.001	[m³]	
3.38	Temperature		T4	25	25	[°C]		T5	25	25	[°C]	T6	25	25	[°C]	
3.39	Density, amount of substance		Rho,N	1.168473	6.96E-06	[kg/m³,kmol]			1.168473	4.03E-05	[kg/m³,kmol]		1.168473	4.03E-05	[kg/m³,kmol]	

3.40	**State at point**		**1**	**2**	**3**	**4**	**5**	**6**	
3.41	Mass	m	0.001168	0.001168	0.000201	0.000201	0.001168	0.001168	[kg]
3.42	Density	Rho	1.168473	4.029841	4.029841	1.168473	1.168473	1.168473	[kg/m³]
3.43	Absolute pressure	p	100	500	500	100	100	100	[kPa]
3.44	Volume	V	0.001	0.00029	0.00005	0.000172	0.001	0.001	[m³]
3.45	Temperature	T	25	159.1006	159.1006	25	25	25	[°C]
3.46	System entropy	S	2.471668	2.368581	0.306779	0.324556	2.471668	2.471668	[J/K]
3.47	**State change from-to**		**1-2** ☑	**2-3** ☑	**3-4** ☑	**4-5** ☑	**5-6** ☐		
3.48	Polytropic exponent	n	1.300	±∞	1.300	±∞	?	**Sum**	
3.49	Entropy change	ΔS	-0.103087	-0.589537	0.017776	0.10166	0	-0.573187	[J/K]
3.50	Change in internal ener	ΔU	0.112705	0	-0.019435	0	0	0.09327	[kJ]
3.51	Change in enthalpy	ΔH	0.157682	0	-0.027191	0	0	0.130491	[kJ]
3.52	Polytropic heat	Q	-0.03722	0	0.006418	0	0	-0.030802	[kJ]
3.53	Boundary work	W	-0.149925	0	0.025853	0	0	-0.124072	[kJ]
3.54	Polytropic pressure worl	Wt	-0.194903	0	0.033609	0	0	-0.161294	[kJ]

3.55 **State diagram p-V and T-S**

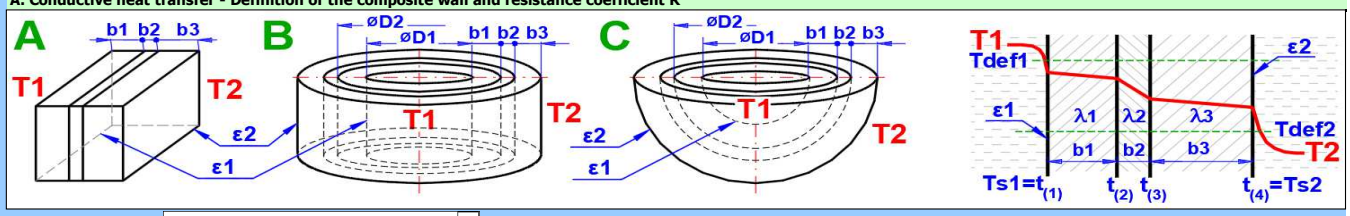


4.0 Heat transfer through the composite wall (radiation + convection => conduction => convection + radiation)

4.1 Boundary conditions

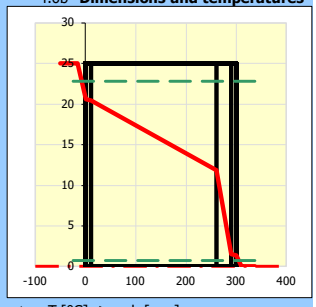
4.2	Medium temperature on the inner (left) side	T1	25	[°C]	Medium temperature on the outer (right) side	T2	0	[°C]
4.3	Pressure	p1	101	[kPa]	Pressure	p2	101	[kPa]

4.4 A. Conductive heat transfer - Definition of the composite wall and resistance coefficient R



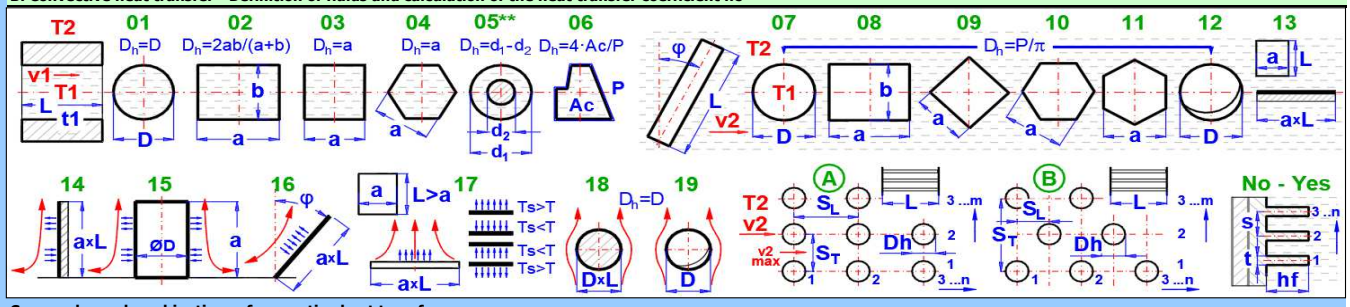
4.5	Wall type	A. Plane wall	
4.6	Material group	2. Building materials (B)	
4.7	Material	010-B. Cement, lime plaster (ρ=1600; λ=0.7; Cp=1100)	3

4.6b **Dimensions and temperatures**



	4.8 **Description and definition of layer parame**	**Diameter** D[mm]	**Thickn.** b[mm]	**Density** ρ[kg/m³]	**Conduct.** λ[W/m/K)]	**Capacity** Cp[J/kg/K]	**Resist.** R[m²K/W]	**Temp.** t[°C]	**Mass** m[kg/m²]
1	Cement, lime plaster	6998	10	1600	0.7	1100	0.014286	20.62374	16
2	Hollow brick	7018	250	975	0.32	1000	0.78125	20.46673	243.75
3	Glass wool	7518	30	35	0.032	1030	0.9375	11.8804	1.05
4	Cement, lime plaster	7578	10	1600	0.7	1100	0.014286	1.576801	16
5		7598						1.419794	
6		7598							
7		7598							
8		7598							
9		7598							
10		7598							
		Σb(i) =	300			ΣR(i) =	1.747321	Σm(i) =	276.8

4.9 B. Convective heat transfer - Definition of fluids and calculation of the heat transfer coefficient hc

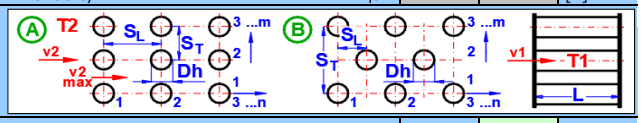


4.10 Commonly used combinations of convective heat transfer

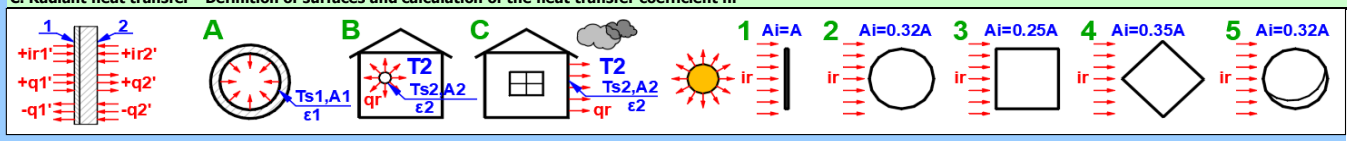
4.11 12. Vertical surface - Free convection (14) <==> Flow across a plate - Forced convection (13)

	1. Medium - Inner (left) side					**2. Medium - Outer (right) side**				
4.12					=►||=►					
4.13	Fluid / Gas	17-G. Air [250...1050K]				Fluid / Gas	17-G. Air [250...1050K]			
4.14	Temperature of the inner (left) side of the wall	Ts1	20.624	20.62374	[°C] ☑	Temperature of the outer (right) side of the wall	Ts2	1.420	1.419794	[°C] ☑
4.15	Definition temperature	Tdef1 = (T1+Ts1)/2 [22.81°C]		22.81187	[°C]	Definition temperature	Tdef2 = (T2+Ts2)/2 [0.71°C]		0.709897	[°C]
4.16	Density	Rho		1.188883	[kg/m³] ☑	Density	Rho		1.284832	[kg/m³] ☑
4.17	Dynamic viscosity	μs, μ	1.82E-05	1.83E-05	[Pa.s]	Dynamic viscosity	μs, μ	1.73E-05	1.73E-05	[Pa.s]
4.18	Specific heat capacity	Cp		1006.184	[J/kg/K]	Specific heat capacity	Cp		1005.093	[J/kg/K]
4.19	Thermal conductivity	λ		2.58E-02	[W/m/K]	Thermal conductivity	λ		2.41E-02	[W/m/K]

4.20	Coefficient of volumetric expansion	β		3.38E-03	[1/K]			Coefficient of volumetric expansion	β		3.65E-03	[1/K]	
4.21	Kinematic viscosity	ν		15.42656	[mm²/s]			Kinematic viscosity	ν		13.44042	[mm²/s]	
4.22	**Flow type: A-Forced convection, B-Natural convection**							**Flow type: A-Forced convection, B-Natural convection**					
4.23	8 - 14. Vertical surface (Heat Transfer Appl. for the PE) ..... [1e3<Ra<1e13]							A - 13. Flow across a plate (Heat Transfer Appl. for the PE) ..... [Re<1e7, 0.1<Pr<1e3 (Turb.0.6<Pr<60)]					
4.24	Flow velocity, Flow rate	v1,m1'	0.001	0.014861	[m/s,kg/s]			Flow velocity, Flow rate	v2,m2'	2	32.12081	[m/s,kg/s]	
4.25	Dimension according to the figure	a	2500	1000	[mm] ☐			Dimension according to the figure	a	2500	2500	[mm] ☑	
4.26	Dimension according to the figure	L	5000	1000	[mm] ☐			Dimension according to the figure	L	5000	5000	[mm] ☑	
4.27	Dimension according to the figure		0	0	☑			Dimension according to the figure		0	0	☑	
4.28	Dimension according to the figure		0	0	☑			Dimension according to the figure		0	0	☑	
4.29	***Finned surface***		No					***Finned surface***		No			
4.30	Finned area	At1	12.905		[m²]			Finned area	At2	114.29		[m²]	
4.31	Fin efficiency	ηof1	0.978347	0.978347	[~] ☑			Fin efficiency	ηof2	0.408474	0.408474	[~] ☑	
4.32	***Tube bank***		Not used										
4.33	Distance between tubes	ST, SL	3183.099	3183.099	[mm] ☑								
4.34	Number of rows / number of columns	m, n	5	3	[~]								
4.35	Number of tubes in the tube bank	N	1	1	[~] ☑								
4.36	Flow velocity between tubes	v2max	9.319585	9.319585	[m/s] ☑								
4.37	Heat transfer area inner (left)	A1	12.5	12.5	[m²] ☑			Heat transfer area outer (right)	A2	12.5	12.5	[m²] ☑	
4.38	Prandtl number	Pr, Prs	0.716095	0.71202	[~]			Prandtl number	Pr, Prs	0.71968	0.72114	[~]	
4.39	Reynolds number, Critical Re	Re, Recrt	0	1E+09	[~]	Iteration		Reynolds number, Critical Re	Re, Recrt	372012.1	500000	[~]	
4.40	Grashofer number, Rayleigh number	Gr, Ra	9.52E+09	6.82E+09	[~]			Grashofer number, Rayleigh number	Gr, Ra	4.4E+09	3.17E+09	[~]	
4.41	Nusselt number, Characteristic dimension	Nu, a	243.6238	2500	[~],[mm]			Nusselt number, Characteristic dimension	Nu, a	362.9727	2500	[~],[mm]	
4.42	Convective heat transfer coefficient	hc1	2.511393	2.51128	[W/m²/K]			Convective heat transfer coefficient	hc2	3.501548	3.501548	[W/m²/K]	
4.43	Heat flux - convection (specific, total)	qc1', Qc1	10.99051	137.3813	[W/m²,W]			Heat flux - convection (specific, total)	qc2', Qc2	4.971476	62.14345	[W/m²,W]	



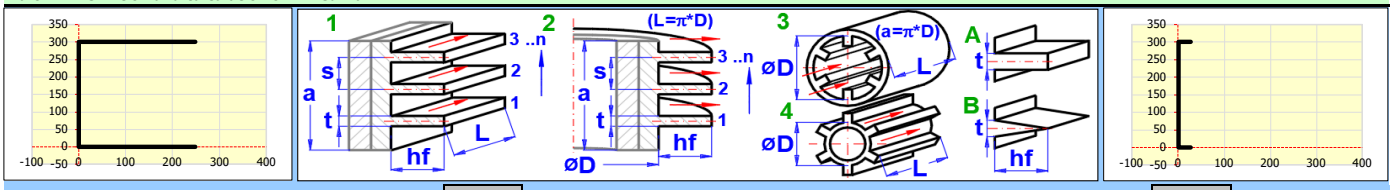
4.44 **C. Radiant heat transfer - Definition of surfaces and calculation of the heat transfer coefficient hr**



4.45	**1. Surface - Inner (left) side**							**2. Surface - Outer (right) side**					
4.46	Material group		1. Metals and metal alloys (M)					Material group		7. Minerals, glass (N)			
4.47	Wall material		032-B. Granite: Rough (ε =0.9)					Wall material		045-B. Plaster: Rough (ε =0.91)			
4.48	Emissivity	ε1	0.900	0.900	[~] ☑			Emissivity	ε2	0.910	0.910	[~] ☑	
4.49	**1. Radiation - From inner (left) side**						||=►	**2. Radiation - From outer (right) side**					
4.50	Heat radiation into space		A. Not used (closed space..)					Heat radiation into space		B. General space radiation			
4.51	Radiating area, inner (left)	Ar1	12.5	12.5	[m²] ☑			Radiating area, outer (right)	Ar2	12.5	12.5	[m²] ☑	
4.52	Radiation heat transfer coefficient	hr1	0		[W/m²/K]			Radiation heat transfer coefficient	hr2	4.23937		[W/m²/K]	
4.53	Heat flux - radiation (specific, total)	qr1', Qr1	0	0	[W/m²,W]			Heat flux - radiation (specific, total)	qr2', Qr2	6.019031	75.23788	[W/m²,W]	
4.54	**1. Irradiation - On inner (left) side**						||	**2. Irradiation - On outer (right) side**					
4.55	Incident radiation intensity	ir1'	0	* 1	[W/m²]			Incident radiation intensity	ir2'	0	* ε	[W/m²]	
4.56	Irradiated area size	Ai1	1.25E+01	1.=A	[m²]			Irradiated area size	Ai2	12.5	1.=A	[m²]	
4.57	Radiation heat transfer coefficient	hi1	0		[W/m²/K]			Radiation heat transfer coefficient	hi2	0		[W/m²/K]	
4.58	Heat flux - irradiation (Ø specific, total)	qi1' ,Qi1	0	0	[W/m²,W]			Heat flux - irradiation (Ø specific, total)	qi2' ,Qi2	0	0	[W/m²,W]	
4.59	**Heat transfer results**													
4.60	**Convection + radiation + irradiation**						=►||=►	**Convection + radiation + irradiation**					
4.61	Heat transfer coefficient	hcri1	2.511393		[W/m²/K]			Heat transfer coefficient	hcri2	7.740919		[W/m²/K]	
4.62	Heat flux - total (specific, total)	qcri1', Qcri1	10.99051	137.3813	[W/m²,W]			Heat flux - total (specific, total)	qcri2', Qcri2	10.99051	137.3813	[W/m²,W]	
4.63	**Overall heat transfer coefficient U, Overall thermal resistance R**							**Overall heat transfer coefficient U, Overall thermal resistance R**					
4.64	Inner (left) surface	U1,R1	0.43962	2.274691	[W/m²/K,m²K/W]			Outer (right) surface	U2,R2	0.43962	2.274691	[W/m²/K]	
4.65	Cylindrical wall	Ucyl1,Rcyl1	1.099051	0.909876	[W/m/K,m.K/W]			Cylindrical wall	Ucyl2,Rcyl2	1.099051	0.909876	[W/m/K]	
4.66	Spherical wall	Usph1,Rsph1	5.495253	0.181975	[W/K,K/W]			Spherical wall	Usph2,Rsph2	5.495253	0.181975	[W/K]	
4.67	Wall thermal resistance (wall only)	Rwall	1.747321		[m²K/W]								
4.68	**Heating / cooling of the working medium**					Parallel flow		**Heating / cooling of the working medium**					
4.69	Flow area	Af1	1.25E+01	12.5	[m²] ☑		=►||=►	Flow area	Af2	1.25E+01	12.5	[m²] ☑	
4.70	Density	Rho	1.180158	1.180158	[kg/m³]			Density	Rho	1.288172	1.288172	[kg/m³]	
4.71	Specific heat capacity	Cp	1006.314	1006.314	[J/kg/K]			Specific heat capacity	Cp	1005.064	1005.064	[J/kg/K]	
4.72	Flow rate	m'	0.014752	[kg/s]				Flow rate	m'	90000	[m³/h]		
4.73	Inlet / Outlet temperature	Tin1,Tout1	25	17.266	[°C]			Inlet / Outlet temperature	Tin2,Tout2	0	0.003547	[°C]	
4.74	Heat flux - mean (specific, total)	qs1',Qs1	9.184974	114.8122	[W/m²,W]			Heat flux - mean (specific, total)	qs2',Qs2	9.184974	114.8122	[W/m²,W]	

4.75	**Saving the wall heat transfer solution**							4.80	**Loading a wall heat transfer solution**					
4.76	Solution name							4.81	Solution selection		16	Date: 20250808 - 17:04:31		
4.77	Structural wall (brick)							4.82	Structural wall (brick) [T1=25 (Air) =>|300mm|=> T2=0 (Air); U1=0.44; q1=11; q2=11]					
4.78	T1=25 (Air) =>|300mm|=> T2=0 (Air); U1=0.44; q1=11; q2=11							4.83	T1=25 (Air) =>|300mm|=> T2=0 (Air); U1=0.44; q1=11; q2=11					
4.79	Structural wall: Plaster, brick, insulation, plaster							4.84	Structural wall: Plaster, brick, insulation, plaster					

4a.0 Definition and calculation of finned wall

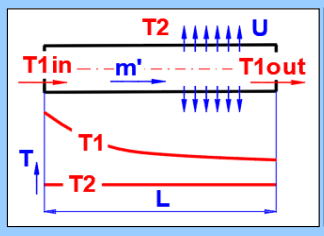


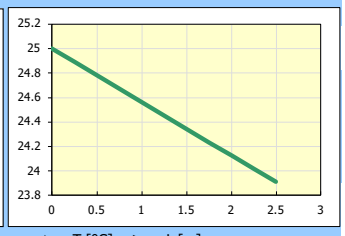
4a.1	**1. Fin type - Internal (left) side**		1					**2. Fin type - External (right) side**		1			
4a.2	Thermal conductivity of fin material	λ	0.7		[W/(m.K)]			Thermal conductivity of fin material	λ	0.7		[W/(m.K)]	
4a.3	Convective heat transfer coefficient	hc1	2.511393		[W/m²/K]			Convective heat transfer coefficient	hc2	3.501548		[W/m²/K]	
4a.4	Wall temperature, medium temperature	Ts1, T1	20.62374	25	[°C]			Wall temperature, medium temperature	Ts2, T2	1.419794	0	[°C]	
4a.5	Finned field width	a	50	5000	[mm] ☐			Finned field width	a	5000	5000	[mm] ☑	
4a.6	Fin profile		A. Rectangle					Fin profile		A. Rectangle			
4a.7	Fin thickness	t	38	38	[mm] ☑			Fin thickness	t	3	38	[mm] ☐	
4a.8	Fin height	hf	100	100	[mm]			Fin height	hf	45	100	[mm]	

4a.9	Distance between fins (fin pitch)	s	86	86	[mm]		Distance between fins (fin pitch)	s	10.7	100	[mm]		
4a.10	Number of fins in the finned field	n	1	=< 1	[~]	☑	Number of fins in the finned field	n	468	=< 468	[~]	☑	
4a.11	Area of one fin / Total area	Af, At	0.595	12.905	[m²]		Area of one fin / Total area	Af, At	0.2325	114.29	[m²]		
4a.12	Parameter x, fin efficiency	x, ηf	1.2614	0.5304	[~]		Parameter x, fin efficiency	x, ηf	1.9302	0.3787	[~]		
4a.13	Overall finned surface efficiency	ηof	0.9783		[~]		Overall finned surface efficiency	ηof	0.4085		[~]		
4a.14	Heat flux - total (specific, overall)	q1',Q1	10.75253	138.7614	[W/m²,W]		Heat flux - total (specific, overall)	q2',Q2	2.03072	232.0909	[W/m²,W]		

5.0 Longitudinal temperature change in piping, temperature change and cooling time in the tank (ISO 12241)

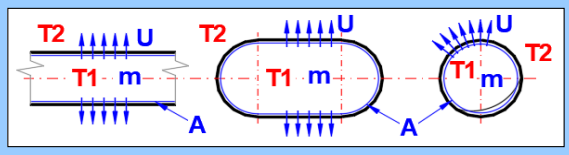
5.1	**Working fluid**	01-L. Water [0...350C]				
5.2	Defining temperature	Tdef	25	25	[°C]	☑
5.3	Specific heat capacity	Cp	4187.655	4187.655	[J/kg/K]	☑
5.4	**Calculation of longitudinal temperature change in piping**					
5.5	Fluid temperature at pipe inlet	T1in	25	25	[°C]	☑
5.6	Ambient temperature	T2	0	0	[°C]	
5.7	Mass flow rate through the piping	m'	0.014752	0.014752	[kg/s]	
5.8	Heat transfer coefficient (cylinder)	Ucyl	1.099051	1.099051	[W/m/K]	
5.9	Distance from the beginning of the pipe	L	2.5	2.5	[m]	☑
5.10	Fluid temperature at point L	T1out	**23.9124**		[°C]	
5.11	Power loss (-) / gain (+)	Pw	**-0.067185479**		[kW]	



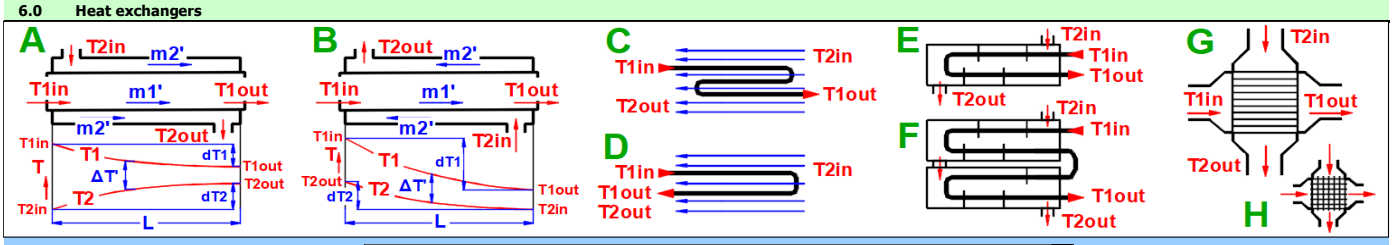


▲y...T [°C], ►x...L [m]

5.12	**Temperature change and cooling time in pipes and tanks**					
5.13	Initial fluid temperature	T1s	25	25	[°C]	☑
5.14	Final fluid temperature	T1e	20	0~25	[°C]	
5.15	Ambient temperature	T2	0	0	[°C]	
5.16	Mass of fluid in the tank	m	0.85		[kg]	
5.17	Heat transfer coefficient (area)	U	0.43962	0.43962	[W/m²/K]	
5.18	Internal area of the tank or pipe	A	12.5	12.5	[m²]	
5.19	Time for cooling / heating	Time	**144.54**		[s]	
5.20	Time for cooling / heating	Time	**0-0:2:24.54**		[d-h:m:s]	
5.21	Energy lost (-) / gained (+)	E	**-0.004943763**		[kWh]	



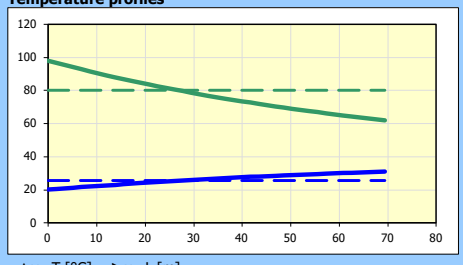
6.0 Heat exchangers



6.1	**Heat exchanger type**	A. Parallel flow heat exchanger (tube-within-a-tube)				
6.2	**Load parameters (select from saved wall definitions / current definition)**					
6.3	List of defined walls	8	Example 16: Oil/water heat exchanger calculation of heat transfer coefficient U [T1=20 (Water) =>)1.5mm)=> T2=98 (SAE 10W); U1=41.421; q1=-3231;			
6.4	Load current parameters from section 4.0 (wall definition)					

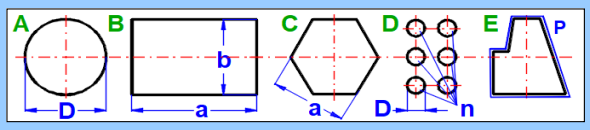
6.5	**Working fluid 1**	01-L. Water [0...350C]					**Working fluid 2**	13-L. SAE 10W [0...100C]			
6.6	Defining temperature	Tdef1	25.4981	25.4981	[°C]	☑	Defining temperature	Tdef2	80	80	[°C] ☑
6.7	Specific heat capacity	Cp1	4187.919	4187.919	[J/kg/K]	☑	Specific heat capacity	Cp2	2132	2132	[J/kg/K] ☑
6.8	**Calculation and working fluid parameters**					=►||=►	**Calculation and working fluid parameters**				
6.9	Mass flow rate	m1'	0.25	0.25	[kg/s]		Mass flow rate	m2'	0.15	0.15	[kg/s]
6.10	Inlet temperature	T1in	20	20	[°C]		Inlet temperature	T2in	98	98	[°C]
6.11	Outlet temperature	T1out	30.9962	30.9962	[°C]		Outlet temperature	T2out	62	62	[°C]
6.12	Temperature difference	dT1,ØT1	10.9962	25.4981	[°C]	Swap	Temperature difference	dT2,ØT2	-36	80	[°C]
6.13	Heat flow rate	Q1	**11.513**		[kW]		Heat flow rate	Q2	**-11.513**		[kW]
6.14	***Calculation of Logarithmic Mean Temperature Difference (LMTD)***										
6.15	Heat capacity rate	C1,C2	1046.98	319.8	[W/K]						
6.16	Coefficients R, P	R, P	0.30545	0.461538	[~]						
6.17	LMTD Correction factor	ε	1	1	[~]	☑					
6.18	Logarithmic Mean Temperature Difference (LMTI	ΔT'	**-50.9389**		[°C]						

6.15a **Temperature profiles**

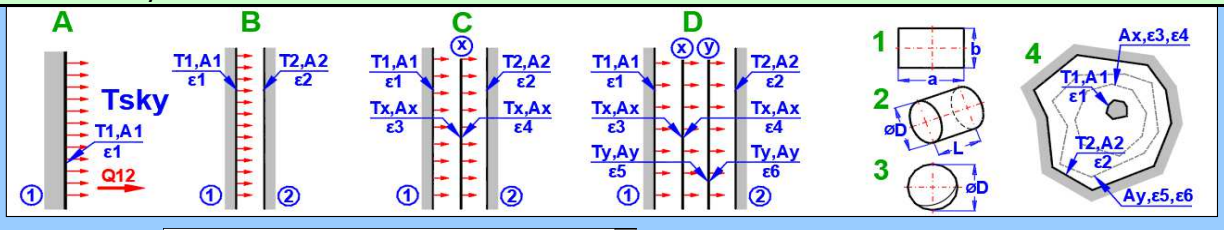


▲y...T [°C], ►x...L [m]

6.19	**Selection and calculation of Heat exchanger parame**	B. Tubular (tube length)				
6.20	***Required tube length of the exchanger***					
6.21	Heat transfer coefficient (cylinder)	Ucyl	3.253179	3.253179	[W/m/K]	☑
6.22	Pipe length	L	**69.47414526**		[m]	
6.23	***Calculation of outlet temperature depending on tube length***					
6.24	Pipe length	L	0.5		[m]	
6.25	Outlet temperature	T1out, T2out	20.12078	97.60459	[°C]	
6.26	Transfer calculated values					
6.27	***Conversion of tube length to area***					
6.28	Tube cross-section	D. Pipe cross-section ... circle				
6.29	Pipe length	L	69.47415	69.47415	[m]	☑
6.30	Inner diameter of the pipe	D	0.3	0.3	[mm]	☑
6.31	Number of pipes	n	1	1	[~]	
6.32	Heat transfer area	A	**0.065477839**		[m²]	
6.33	***Determination of heat transfer coefficient with fouling***					
6.34	U - Clean surface	Uc	41.42077	41.42077	[W/m²/K]	☑
6.35	Fouling factor	Rf	1		[m²K/W]	
6.36	U - Fouled surface	Ud	0.976427	Δ=-98%	[W/m²/K]	



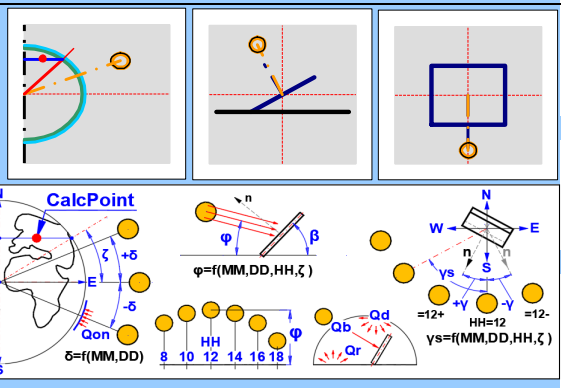
7.0 Heat transfer by radiation



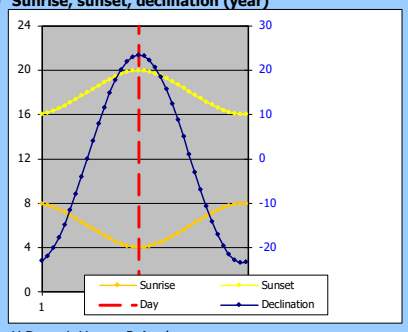
7.1	**Solved task**	B. Two parallel surfaces												
7.2	**Surface number 1**						=►=►		**Surface number 2**					
7.3	Material group	1. Metals and metal alloys (M)						Material group	1. Metals and metal alloys (M)					
7.4	Wall material	199-M. Stainless Steel: type 18-8, polished (ε = 0.10 - 0.19)						Wall material	199-M. Stainless Steel: type 18-8, polished (ε = 0.10 - 0.19)					
7.5	Wall emissivity		ε1	0.93	0.15	[~]		Wall emissivity		ε2	0.736	0.15	[~]	
7.6	Wall temperature		T1	200	27	[°C]		Wall temperature		T2	20		[°C]	
7.7	Area calculation	2. Cylindrical surface (π*D*L)	D1,L1	200	1000	[mm]		Area calculation		D2,L2	2000	1000	[mm]	
7.8	Wall area		A1	0.628319	0.628319	[m²]		Wall area		A2	6.283185	6.283185	[m²]	
7.9		**Shielding foil X**							**Shielding foil Y**					
7.10		Shielding emissivity	ε3, ε4	0.05	0.05	[~]			Shielding emissivity	ε5, ε6	0.33	0.6	[~]	
7.11		Area calculation	Dx,Lx	1000	1000	[mm]			Area calculation	Dy,Ly	1000	1000	[mm]	
7.12		Foil area	Ax	5.969026	5.969026	[m²]			Foil area	Ay	3.141593	3.141593	[m²]	
7.13		Foil temperature	Tx	~		[°C]			Foil temperature	Ty	~		[°C]	
7.14	**Heat flux (specific, total)**		**q12',Q12**	2180.757	1370.21	[W/m²,W]		**Heat flux (specific, total)**		**q21',Q21**	-218.0757	-1370.21	[W/m²,W]	
7.15	**Radiation heat transfer coefficient**		**hr12**	12.11532		[W/m²/K]		**Radiation heat transfer coefficient**		**hr21**	1.211532		[W/m²/K]	

8.0 Solar radiation

8.1	**Solar radiation**		MM:8	DD:21	HH:18.9		
8.2	Month (1-12), day (1-31)	MM,DD	6		21	5	[m,d]
8.3	Hour (0-24), latitude (±90)	HH,ζ	12	1	48.9	5	[h],[°]
8.4	Surface tilt (0-90), surface azimuth (±180)	β,γ	30	5	0	5	[°],[°]
8.5	Sunrise, sunset, daylight duration	h1,h2,h3	4:0	19:59	15:58		[h:m]
8.6	Solar elevation (angle above horizon), declinatio	φ,δ	64.54978	23.44978			[°]
8.7	Solar irradiance (solar constant)	Qon	1322.624	1322.624			[W/m²]
8.8	Altitude	Alt	35	0			[m]
8.9	Atmospheric pollution coefficient (1.5-6)	Z	5	5			[~]
8.10	Sun azimuth, sun angle to surface normal	γs,θ	0	4.549783			[°]
8.11	Radiant power on a defined / perpendicular surf	QbT,Qbn	775.0822	777.5324			[W/m²]
8.12	Diffuse radiation on a defined / horizontal surfac	QdT,Qd	151.5441	162.4244			[W/m²]
8.13	Ground reflectivity (albedo)	Rhog	0.2	0.2			[~]
8.14	Reflected solar radiation on a given surface	QrT	11.58216				[W/m²]
8.15	Surface area	As	1				[m²]
8.16	Total solar irradiance (QbT+QdT+QrT)	QT,QTs	938.2084	938.2084			[W/m²,W]
8.17	Energy conversion efficiency	Eff	100	100 %			[%]
8.18	Surface power	Q,Qs	938.2084	938.2084			[W/m²,W]
8.19	Daily surface energy	Pw,Pws	8.019433	8.019433			[kWh/m²,kWh]

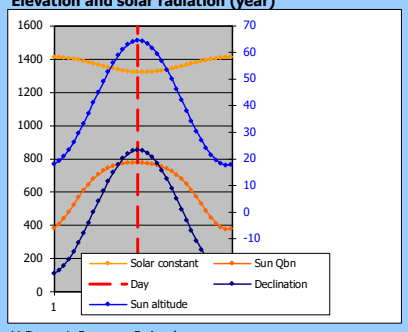


8.20 **Sunrise, sunset, declination (year)**



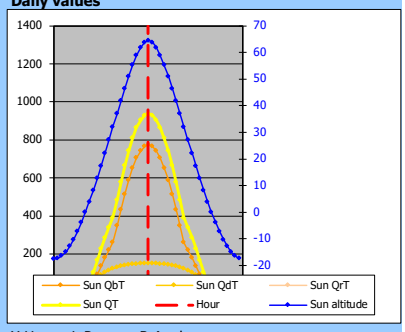
X:Day, yL:Hour, yR:Angle

8.21 **Elevation and solar radiation (year)**



X:Day, yL:Power, yR:Angle

8.22 **Daily values**



X:Hour, yL:Power, yR:Angle