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***Content Based
Chemical Engineering***

Heat Transfer in Jacketed Vessels
Version 2.03a

by Stephen M. Hall, PE
Copyright 2001
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All cells are locked except user-defined data; unlock sheet from Tools menu (no password required)
VIEW-COMMENTS to see some additional explanations.
Scroll down and to the right to enter data.

Project Data			
Prepared by	xx	Client	xx
Date	xx	W.O.	xx
		Unit	xx
		Area	xx
		Equip No	xx
<input checked="" type="radio"/> Customary US <input type="radio"/> SI			

To restore a saved calculation, select it from the drop-down box below, then click the "Restore Saved Calculation" button

Temperature Conversion			
Enter value to convert:			
550 °F	=		287.78 °C
270 °C	=		518.00 °F

Vessel Data			
Calc Title or Description	Pfaudler RT-32-100 Glass-Lined Reactor		
Orientation	vertical	vol to tangent	
Total working volume	gallons	116.9	116.34
Inside diameter	inches	32	
Tangent-to-tangent	inches	22.75	
Heads	Hemispherical Dished ▼		
Material of construction	carbon steel ▼		
Thickness	inches	0.63	
Lining	Glass ▼		
Thickness	inches	0.06	
Internal surface roughness	inches	0.000005	
Outside surface roughness	inches	0.007	
Internal fouling factor	ft ² -hr-°F/Btu	0	
Outside fouling factor (jacket)	ft ² -hr-°F/Btu	0.001	
<input checked="" type="checkbox"/> Tank is Baffled			

Jacket Fluid Data			
Fluid name	Dowtherm SR-1, 20 vol% ▼		
Temperature at jacket inlet	°F	40.0	
Properties from data table:			
Thermal Conductivity	Btu/h-ft-°F	0.28	
Specific Heat	Btu/lb-°F	0.90	
Density	lb/ft ³	64.79	
Viscosity	cP	2.60	
	lb/ft-h	6.29	
Prandtl Number	dimensionless	20.44	

Vessel Fluid Data			
Name	Water		
Bulk Temp	°F	100.0	
Thermal Conductivity	Btu/h-ft-°F	0.36	
Specific Heat	Btu/lb-°F	0.99	
Density	lb/ft ³	62.12	
Viscosity	cP	0.68000	
	lb/ft-h	1.65	
Viscosity at wall	cP	0.77833	
	lb/ft-h	1.88	

Side-Wall Jacket			
<input type="radio"/> No Jacket <input checked="" type="radio"/> Conventional			
<input type="radio"/> Half-Pipe Coil <input type="radio"/> Dimple			
Inlet/Outlet Nozzle Size	inches	4	▼
Number of Zones		1	
Percentage of side-wall covered by jacket		1	

Flow Rate in Side-Wall Jacket			
<input type="radio"/> Specify flow rate per zone			
<input checked="" type="radio"/> Target velocity in jacket			
<input type="radio"/> Target pressure drop			
Target velocity	ft/sec	10	
<input checked="" type="checkbox"/> Use Experimental Pressure Drop Data			
<input type="checkbox"/> Sidewall			
<input type="checkbox"/> Bottom Head			

Agitator Data			
Impeller Type	Glass-steel retreating ▼		
Impeller Diameter	inches	24	
Blade Height or Flight Pitch	inches	2	
Blade Pitch (90 deg = upright)	degrees	90	
Number of blades		3	
Agitator Rotational Speed	rpm	15	

Half-Pipe Coil Jacket Data		
Not Applicable		
Nominal Pipe Diameter	inches	2
Cross section angle (180 or 120 deg)		120
Spacing between Coils	inches	0.9843
Conventional Jacket Data		
Annular space dimension	inches	1.37
<input type="radio"/> Standard <input type="radio"/> Baffled <input checked="" type="radio"/> Agit. Nozzles		
Number of agitation nozzles per zone		1
Throat diameter for each nozzle	inches	0.625
		2.36
<input type="checkbox"/> Aiding flow (upflow during cooling/downflow during heating)		
Dimple Jacket Data		
Not Applicable		
Annular space dimension	inches	0.1969
Center-to-center distance between adjacent dimples		
Longitudinal	inches	3.94
Transverse	inches	3.94
Mean dimple diameter	inches	3.54
Dimple pitch	<input type="radio"/> Triangular <input checked="" type="radio"/> Square	
Bottom Head Jacket		
<input type="radio"/> No Jacket <input type="radio"/> Conventional		
<input type="radio"/> Half-Pipe Coil <input type="radio"/> Dimple		
<input checked="" type="radio"/> Same type as Side-Wall Jacket		
<input type="checkbox"/> Series Flow		
Number of agitation nozzles on bottom		0
Internal Coil		
<input checked="" type="radio"/> No Coil <input type="radio"/> Helical <input type="radio"/> Hairpin		
Coil pipe size	inches	2
Length of coil	inches	672.1

Quick Results					
Heat Transfer Coefficients		hi	ho	Overall U	
From Vessel to Sidewall Jacket		198	76	33 Btu/ft ² -hr-°F	
From Vessel to Bottom Jacket		198	76	33 Btu/ft ² -hr-°F	
From Vessel to Coil		--	--	-- Btu/ft ² -hr-°F	
Fluid Flow		Flow Rate		Velocity	Pressure Drop
Sidewall Jacket (each nozzle)		9.6 gal/min		10.0 ft/sec	1.6 psi
Sidewall Jacket (combined)		9.6 gal/min		10.0 ft/sec	1.6 psi
Bottom Jacket Nozzle		0.0 gal/min		10.0 ft/sec	1.6 psi
Internal Coil		-- gal/min		-- ft/sec	-- psi
Temperature Effects		Inlet	Outlet	Heat Transferred	
Sidewall Jacket		40.0	47.0 °F	-31,296	Btu/hr
Bottom Jacket		40.0	0.0 °F		Btu/hr
Internal Coil		--	-- °F	--	Btu/hr
Vessel Contents		100.0	°F		Btu/hr
Vessel contents will cool at a rate of 0.55 °F/minute					

Use this section when you have experimental pressure drop data		
Input the known conditions		
Flowrate	Density	Pressure Drop
gal/min	lb/ft ³	psi
Sidewall (one zone)		
Bottom Head		
See the instruction manual for further information about the use of this pressure drop technique.		

				JACKETED VESSEL HEAT TRANSFER		
				CLIENT	EQUIP. NO	PAGE
				xx	xx	
REV	PREPARED BY	DATE	APPROVAL	W.O.	REQUISITION NO.	SPECIFICATION NO.
0	xx	xx		xx		
1				UNIT	AREA	
2				xx	xx	PROCURED BY INSTALLED BY
Pfaudler RT-32-100 Glass-Lined Reactor						
1	Vessel Data					
2	Orientation	vertical, cylindrical			Contents	Water
3	Total working volume	116 gallons			Bulk Temperature	100 °F
4	Inside diameter	32 inches			Thermal Conductivity	0.36 Btu/h-ft-°F
5	Tangent-to-tangent	22.75 inches			Specific Heat	0.99 Btu/lb-°F
6	Heads	Hemispherical Dished			Density	62.12 lb/ft³
7	Material of construction	carbon steel			Viscosity	0.68 cP
8	Thickness	0.63 inches				1.645 lb/ft-h
9	Lining	Glass			Viscosity at wall	0.78 cP
10	Thickness	0.06 inches				1.883 lb/ft-h
11	Internal surface roughness	0.0000 inches			Agitator Type	Glass-steel retreating
12	Outside surface roughness	0.0070 inches			Impeller Diameter	24 inches
13	Internal fouling factor	0 ft²-hr-°F/Btu			Speed	15 rpm
14	Outside fouling factor (jacket)	0.001 ft²-hr-°F/Btu				
15	Vessel is baffled					
16	Jacket Fluid					
17	Method for determining flow rate in jacket or coil:				Fluid Name	Dowtherm SR-1, 20 vol%
18	Target Velocity				Temperature at jacket inl	40 °F
19	Value 10 ft/sec				Thermal Conductivity	0.28 Btu/h-ft-°F
20	Pressure drop in sidewall determines flow in bottom jacket				Specific Heat	0.90 Btu/lb-°F
21	Dowtherm SR-1, 20 vol%				Density	64.79 lb/ft³
22	Dow Chemical Co.				Viscosity	2.60 cP
23	Ethylene Glycol, water, and inhibitors					6.29 lb/ft-h
24	Estimated vessel wall temp. 83 °F				Prandtl Number	20.44 dimensionless
25						
26	Jacket and Coil Data					
27	Sidewall Jacket Type	Conventional	Annular space: 1.4 inches; 1 zones; opposing flow			
28			agitating nozzles			
29	Bottom Jacket Type	Conventional	Annular space: 1.4			
30						
31	Internal Coil Type	No Coil				
32						
33						
34	Calculated Results					
35	Heat Transfer Coefficients		hi	hw	ho	Overall U
36	From Vessel to Sidewall Jacket		198	94	76	33 Btu/ft²-hr-°F
37	From Vessel to Bottom Jacket		198	94	76	33 Btu/ft²-hr-°F
38	From Vessel to Coil		--	--	--	-- Btu/ft²-hr-°F
39						
40	Fluid Flow		Flow Rate		Velocity	Pressure Drop
41	Sidewall Jacket (each nozzle)		9.6 gal/min		10.0 ft/sec	1.6 psi
42	Sidewall Jacket (combined)		9.6 gal/min		10.0 ft/sec	1.6 psi
43	Bottom Jacket Nozzle		0.0 gal/min		10.0 ft/sec	1.6 psi
44	Internal Coil		-- gal/min		-- ft/sec	-- psi
45						
46	Temperature Effects		Inlet	Outlet	Heat Transferred	
47	Sidewall Jacket		40.0	47.0 °F	-31,296 Btu/hr	
48	Bottom Jacket		40.0	0.0 °F	Btu/hr	
49	Internal Coil		--	-- °F	-- Btu/hr	
50	Vessel Contents		100.0	°F	-31,296 Btu/hr	
51	Vessel contents will cool at a rate of 0.55 °F/minute					
52						

				JACKETED VESSEL HEAT TRANSFER		
				CLIENT	EQUIP. NO	PAGE
REV	PREPARED BY	DATE	APPROVAL	W.O.	REQUISITION NO.	SPECIFICATION NO.
0	xx	xx		xx		
1				UNIT	AREA	
2				xx	xx	

Pfaudler RT-32-100 Glass-Lined Reactor

1	Vessel Data					
2	Orientation	vertical, cylindrical	Contents		Water	
3	Total working volume	116.9 gallons	Initial Temperature		100 °F	
4	Inside diameter	32 inches	Thermal Conductivity		0.36 Btu/h-ft-°F	
5	Tangent-to-tangent	22.75 inches	Specific Heat		0.99 Btu/lb-°F	
6	Heads	Hemispherical Dished	Density		62.12 lb/ft³	
7	Material of construction	carbon steel	Viscosity		0.68 cP	
8	Thickness	0.63 inches	Viscosity at wall		1.645 lb/ft-h	
9	Lining	Glass			0.78 cP	
10	Thickness	0.06 inches	Agitator Type		Glass-steel retreating	
11	Internal surface roughness	0.0000 inches	Impeller Diameter		24 inches	
12	Outside surface roughness	0.0070 inches	Speed		15 rpm	
13	Internal fouling factor	0 ft²-hr-°F/Btu				
14	Outside fouling factor (jacket)	0.001 ft²-hr-°F/Btu				
15	Vessel is baffled					

16	Jacket Fluid					
17	Method for determining flow rate in jacket or coil:		Fluid Name		Dowtherm SR-1, 20 vol%	
18	Target Velocity		Temperature at jacket inl		40 °F	
19	Value	10 ft/sec	Thermal Conductivity		0.28 Btu/h-ft-°F	
20			Specific Heat		0.90 Btu/lb-°F	
21	Pressure drop in sidewall determines flow in bottom jacket		Density		64.79 lb/ft³	
22			Viscosity		2.60 cP	
23					6.29 lb/ft-h	
24	Estimated vessel wall temp.	83 °F	Prandtl Number		20.44 dimensionless	
25						

26	Jacket and Coil Data					
27	Sidewall Jacket Type	Conventional	Annular space: 1.4 inches; 1 zones; opposing flow			
28			agitating nozzles			
29	Bottom Jacket Type	Conventional	Annular space: 1.4			
30						
31	Internal Coil Type	No Coil				
32						
33						

Timeline (calculated at 5-minute intervals)

