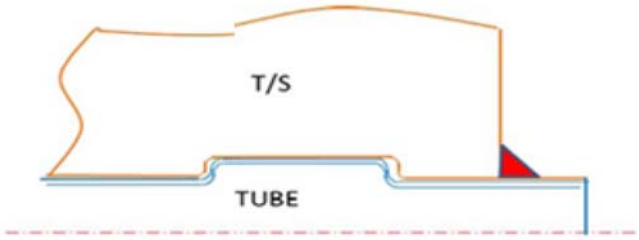
HEAT EXCHANGER ENGINEERING

TUBE EXPANDING STRESS

INPUT DATA 계산실행 ***V2.1 Pgm By Ryu-ChangMyong/P.E***

* ITEM NO.			* DESCRIPTION		
* Tube Outside Dia. Pre-Expanding, D	19.05	mm	* Tube Inside Dia.-Pre-Expanding,d1	17.45	mm
* Tube Inside Dia.-After-Expanding,d2	18.3	mm	* Tube Sheet Hole Dia.Dt	20.05	mm
* Select Tube Material	Stainless Steel		* Groove Width, w	3	mm
* Tube seal weld size,Z	3	mm	* Tube Modulus of elastisity,Es	21100	Kg/mm^2
* Select Shell Material	Carbon Steel		* Design pressure-tube side,P	0.1	Kg/mm^2
* Allowable tube tension stress, Sa	14.01	Kg/mm^2	* Allowable yield stress, Sy	20	Kg/mm^2
* Tube sheet to tube sheet length, L	8576	mm	* Shell side operating temperature, Ts	40	oC
* Tube quanty,N	1210		* Tube side operating temperature, Tt	100	oC
* Tube Max. tensile stress, Su	52	Kg/mm^2			



RESULT OF CALCULATION

1. EXPANDING RATE

1. Tube expanding rate,ra	-9.37%		2. Expanding rate-Allowable	7~9	%
3. Expanding rate-Tarket rate	8	%	4. Expanding rate-Maximum	<12	%
5. Tube thickness reduction,d3	-0.43	mm			
6. Thermal difference between Shell and Tube, λ				2.52	mm

2. EXPANDING STRESS

1 Tube Final thickness, ta	0.38	mm	2. Required tube thickness, tr As per UG-31A & APPENDIX 1.1-1A	0.07	mm
* Judgement, ta > tr then, O.K otherwise, check!				O.K	

3.Tube thermal expansion rate, ε= λ/L	0.00029		4. Tube expanding sectional area ,A	22.0	mm^2
5. Tube thermal force in expanding stress,Ft=AEε	136.5	kgf	6. Tube thermal stress in expanding area, σ1=Ft/A= E λ/L	6.2	kgf/mm^2
* Judgement, σ1 < Sa--->O.K otherwise, Check!				O.K	
7. Tube inertia moment in expanding area, I= π*(D^4-d2^4)/64	959.5	mm^4	8. Modulus of section in expanding area, Z=I/(D/2)	100.7	mm^3
9. Bending Moment in expanding area,M=F*((d2/2)+ta)	1,300	kgf-mm	10. Bending stress in expanding area,σ2=M/Z	12.9	kgf/mm^2
* Judgement, σ2 < Sy*0.66--->O.K otherwise, check!				O.K	

3. TUBE SEAL WELD STRENGTH

1 Weld strength, Ws=Ft/(π*D*Z/2)	1.52	kgf/mm^2	2. Allowable strength, Sa=Sy*0.5	10.0	kgf/mm^2
* Judgement, if Sa > Ws then, O.K, otherwise, check				O.K	

4. FATIGUE ANALYSIS (By Goodman's Diagram)

1. 튜브 최대 응력, σmax=Sy	20.0	kgf/mm^2	2. 튜브 최소 응력, σmin=σ1	6.2	kgf/mm^2
3. 최대 인장 강도, Su	52.0	kgf/mm^2	4. 피로한도, Se1 =Su*0.39	20.3	kgf/mm^2
5. 튜브 피로 수명, L1	1,000,000	cycle	6. 응력진폭, σa= (σmax- σmin)/2	6.9	kgf/mm^2
7. 평균 응력, σm= (σmax+σmin)/2	13.1	kgf/mm^2	8. 허용피로한도, Se2=σa/(1-(σm/su))	9.2	kgf/mm^2
9. 피로한도율 =Se2/Se1	45.5	%	10. 허용피로수명, L2	454,723	cycle
11. 피로 수명(시간)	7,579	hr	12. 피로수명(년)	0.9	year

5. RECOMMENDED TUBE USED THICKNESS-THERMAL STRESS

1.확관부 열응력 요구 두께,t1=(σ1*π*D*w)/2)/π*D*Sa)	0.66	mm	2. Actual tube thickness, t2	0.80	mm
3. 튜브 사용 두께, ta1=(Dt-2t1/1-ra)/2	1.17	mm			
* Judgement, if ta1 < t2 then, O.K, otherwise, check				Check !	

6. RECOMMENDED TUBE USED THICKNESS-BENDING STRESS

1.Expanding rate,ε1=λ/L=(t2-ta)/t2	0.5313		2. Curvature, k=(π*r*Θ/180) /w (Θ =67.1)	0.2833	mm
3.Bending moment, M	1,300	kgf-mm	4. Modulus of section, Z=M/Sa	92.8	mm^3
5. 튜브 사용 두께,ta2=D-(D^3-32Z/π)^1/3)/2	0.48	mm	6. Actual tube thickness, t2	0.80	mm
* Judgement, if ta2 < t2 then, O.K, otherwise, check				O.K	

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