# HEAT EXCHANGER ENGINEERING

## TUBE THINNING EXPECTANCY ANALYSIS

**INPUT DATA** 계산실행 *V1.0 Pgm By Ryu-ChangMyong/P.E*

| | | | | | |
|---|---|---|---|---|---|
| * ITEM NO. | E-1004 | | * DESCRIPTION | SAMPLE | |
| * Tube Outside Dia.-New, D | 19.05 | mm | * Tube Inside Dia.New,d1 | 16.85 | mm |
| * Tube Inside Dia.-After-Thinning,d2 | 16.20 | mm | * Tube Sheet Hole Dia. | 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 | 1.2 | 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 | * Fatigue life | 2000000 | cycle |

### *RESULT OF CALCULATION*

#### *1. TUBE THINNING RATE*

| | | | | | |
|---|---|---|---|---|---|
| 1. Tube thinning rate | -29.55% | | 2.Tube thickness reduction,d3 | 0.33 | mm |

#### *2. TUBE THERMAL STRESS*

| | | | | | |
|---|---|---|---|---|---|
| 1.Thermal difference between Shell and Tube, λ | 2.52 | mm | 2. Required tube thickness, tr As per UG-31A & APPENDIX 1.1-1A | 0.83 | mm |
| 3.Tube Final thickness, ta | 1.43 | mm | * Judgement | O.K | |
| 4.Tube thermal expansion rate, ε=λ/L | 0.00029 | mm | 5. Tube expanding sectional area ,A | 78.9 | mm^2 |
| 6. Tube thermal force in expanding stress,F=AEε | 489.5 | kgf | 7. Tube thermal stress in expanding area, σ1=F/A | 6.2 | kgf/mm^2 |
| * Judgement, σ1 < Sa--->O.K otherwise, Check! | | | | O.K | |
| 8. Tube inertia moment in expanding area, I=π*(D^4-d2^4)/64 | 3,083.7 | mm^4 | 9. Modulus of section in expanding area, Z=I/(D/2) | 323.8 | mm^3 |
| 10. Bending Moment in expanding area,M=F*((d2/2) | 4,662.04 | kgf-mm | 11. Bending stress in expanding area,σ2=M/Z | 14.4 | kgf/mm^2 |

+ta)

| | | |
|---|---|---|
| * Judgement, σ2 < Sy*0.66--->O.K otherwise, check! | Check ! | |

### 3. TUBE SEAL WELD STRENGTH

| | | | | | |
|---|---|---|---|---|---|
| 1 Weld strength, Ws=F/π*D*Z | 2.73 | kgf/mm^2 | 2. Allowable strength, Sa=Sy*0.66 | 13.2 | kgf/mm^2 |
| * Judgement | | | | O.K | |

### 4. FATIGUE ANALYSIS ( By Goodman's Diagram)

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|---|---|---|---|---|---|
| 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 | 20.3 | kgf/mm^2 |
| 5. 튜브 피로 수명, L1 | 2,000,000 | 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 | 909,446 | cycle |
| 11. 피로 수명(시간) | 36,757 | hr | 12. 피로수명(년) | 4.2 | year |

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