최적설계 프로젝트
1차 발표

보온병(의) 신

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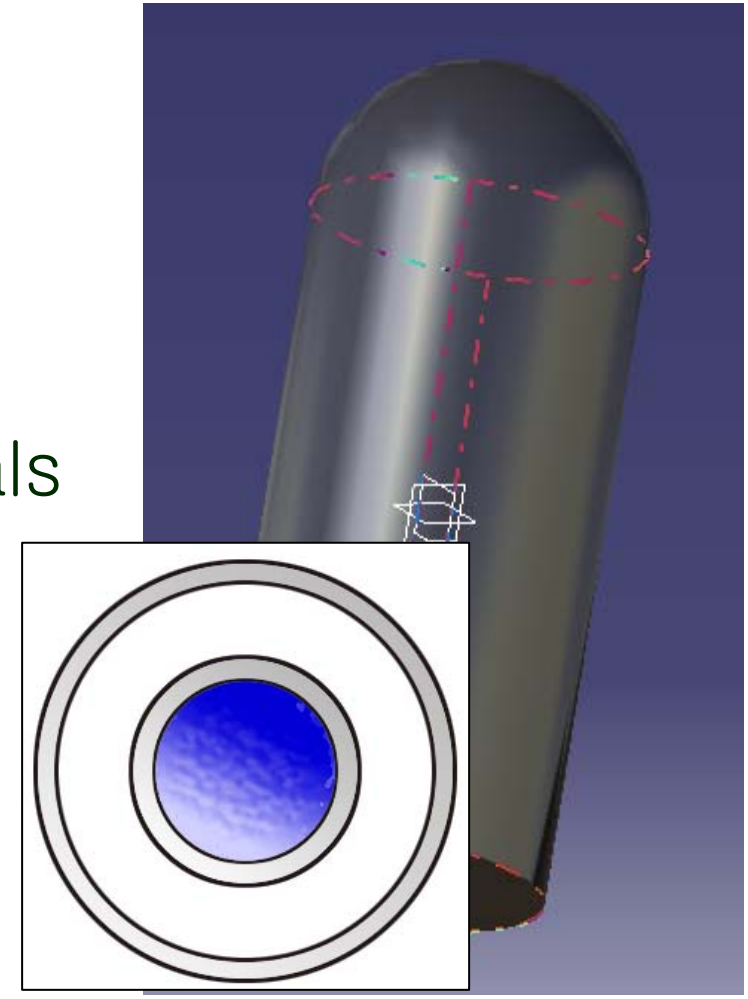
Introduction

- Thermos bottle design
- Theory in the project
  - Heat Transfer
  - Mechanics of Materials
- Tools for the Solution
  - Excel
  - MATLAB(2차)



Step1. Project Statement

LOGO

- 500mL 보온병의 설계
- 재료는 STS304를 사용
- 구속조건을 만족해야 함
- 중량을 최소화 하는 500mL 용량의 보온병 설계

Step2. Data & Information Collection

LOGO

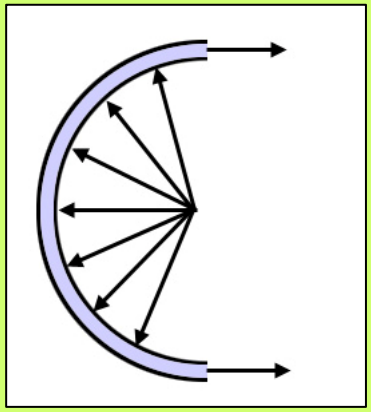
- STS304의 인장강도 205MPa
- STS304의 비중 7.93, $K_{STS304} = 13.2\ \mathrm{W/mK}$
- 시중의 스테인레스 진공 보온병의 두께 0.3mm

Thin-walled pressure vessel

$$\sum F_x = 2F_\theta - \sum dP_r \sin\theta = 0$$

$$2F_\theta - \int dP_r \sin\theta = 2F_\theta - \int (pLr_i d\theta)\sin\theta = 0$$

$$\sigma_\theta = \frac{F_\theta}{tL} = \frac{pd}{2t} = \frac{pr}{t}$$



Step2. Data & Information Collection

LOGO

- Theorem 2

Heat conduction in cylinders,

$$\frac{1}{r}\frac{d}{dr}\left(kr\frac{dT}{dr}\right)=0$$

General solution of upper eqn. is

$$T(r)=C_1\ln r+C_2$$

Thus, the heat transfer rate is

$$Q'=-k(2\pi rL)\frac{\partial T}{\partial r}=\frac{2\pi kL(T_i-T_0)}{\ln(r_0/r_i)}=\frac{T_i-T_0}{\ln\left(r_0/r_i\right)/2\pi kL}$$

Step2. Data & Information Collection

LOGO

- Theorem 3

  Heat transfer from finned surfaces

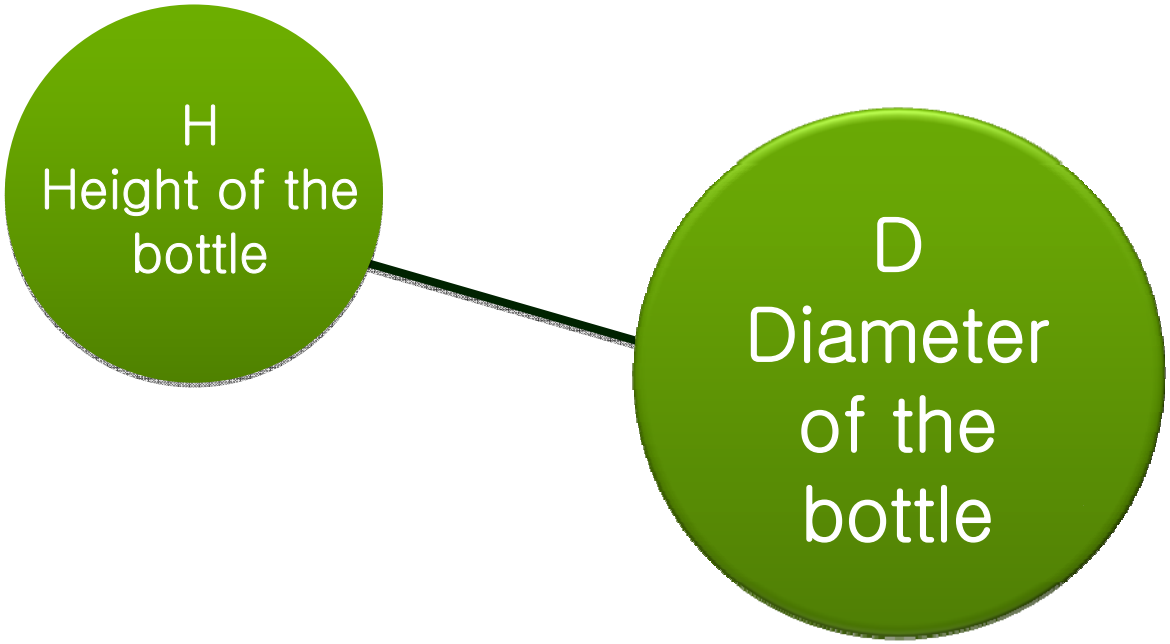
  Assume that the upper side of Thermos bottle is like a thin fin. And spread the rolled surface, as width is pi*D.

$$\frac{\theta}{\theta_0} = \frac{\cosh m(L-x)}{\cosh mL}$$

  Case : there is no heat flow in the tip

$$Q'_{fin} = -kA\frac{d\theta}{dx} = \sqrt{kAhP\theta_0}\tanh mL$$

Step3. Design Variables



Step4. Cost Function

- 재료는 STS304로 동일
- 최소부피가 최소비용

$$f = \frac{\pi}{4}D^2t + \pi D\frac{3}{4}ht + \{\pi D - \pi(D - 0.5\times 2)\}t + \frac{\pi}{4}(D-1)^2t + (h-0.5)\pi(D-1)t$$

- t는 병의 두께로 주어진 값

Step5. Constraints

- Constraint 1
- 보온병 접촉부분의 전도에 의한 에너지

$$\frac{T_i - T_0}{\frac{D}{\ln \frac{D}{D-1}}} \leq 1.5W$$

$$2\pi kt$$

$$D \leq 8.047326cm$$

Step5. Constraints

LOGO

- Constraint 2

$$\sqrt{k\pi(D-1)t\cdot h\cdot 2\{\pi(D-1)+t\}}(T_i-T_\infty)\tanh\sqrt{\frac{hP}{kA}}L\le 1.5W$$

$$mL\simeq\sqrt{\frac{2h}{kA_m}}L^{\frac{3}{2}},\ A_m=t\cdot L$$

thus,

$$2.34502D^2-35.67129D+123.67551\le 0$$

Step5. Constraints

LOGO

- Constraint 3

$$\frac{\pi}{4}(D-1)^2 \times (H-0.5) = 500$$

- Constraint 4

$$\sigma_\theta = \frac{\mathrm{Pr}}{t} \qquad P = \rho_{water} g h$$

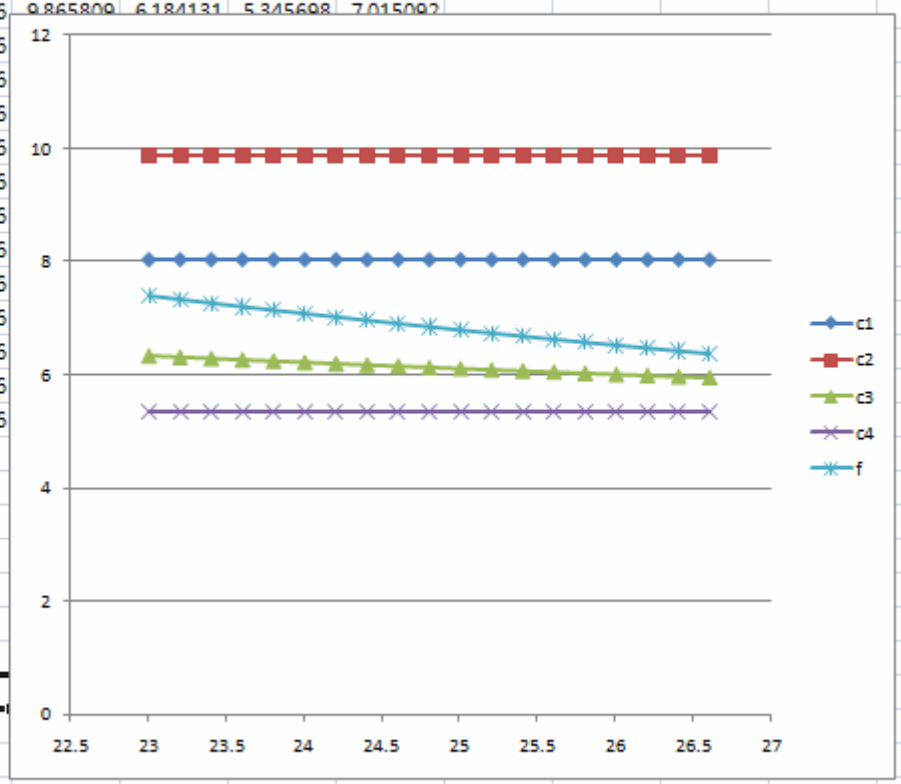
inside $\sigma_\theta = \dfrac{P(\frac{d}{2} - 0.0056)}{0.0003}$ outside $\dfrac{\mathrm{Pr}}{t}, \quad P = 0$

$$\sigma_\theta = 1.3573 \times 10^6 \{600d - 3.6\} \le 68.333 \times 10^6$$

$$d \le 0.089908 \text{ m}$$

The solution of the project

	A	B	C	D	E	F	G	H	I	J	K	L	M
5			23	8.037426	9.865809	6.320579	5.345698	7.381097					
6			23.2	8.037426	9.865809	6.297089	5.345698	7.317467					
7			23.4	8.037426	9.865809	6.273907	5.345698	7.254925					
8			23.6	8.037426	9.865809	6.251026	5.345698	7.193442					
9			23.8	8.037426	9.865809	6.228441	5.345698	7.132993					
10			24	8.037426	9.865809	6.206145	5.345698	7.073551					
11			24.2	8.037426	9.865809	6.184131	5.345698	7.015092					
12			24.4	8.037426									
13			24.6	8.037426									
14			24.8	8.037426									
15			25	8.037426									
16			25.2	8.037426									
17			25.4	8.037426									
18			25.6	8.037426									
19			25.8	8.037426									
20			26	8.037426									
21			26.2	8.037426									
22			26.4	8.037426									
23			26.6	8.037426									
24													
25													
26													
27													
28		초기값	해찾기										
29	f	17.8166	14.05377										
30	D	6.8	5.392849										
31	H	27.8	27.65052										
32	c1	-1.23743	-2.64458										
33	c2	-3.06581	0										
34	c3	220.922	-88.7173										
35	c4	1.454302	0.047151										
36	c5	5.8	5.650523										



❖ 감사합니다.