JK와 함께 트램펄린운동으로 아름다운 몸매를!

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1. Statement

2. Data and Information Collection

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1. Statemen

몸무게가 100kg 나가는 녀의 목표는 바로 김아중! 다이어트를 위 을 선택하였다.

트램펄린에 달린 용수철 하나 당 길이 (L)는 20cm라고 한다.

이 여성이 사용했을 때 cm이하가 되도록 하는 용수철의 최소 si

용수철은 Helical M 229 wire 이다. (단, 용수철 작용하고 각 용수철에는 같은

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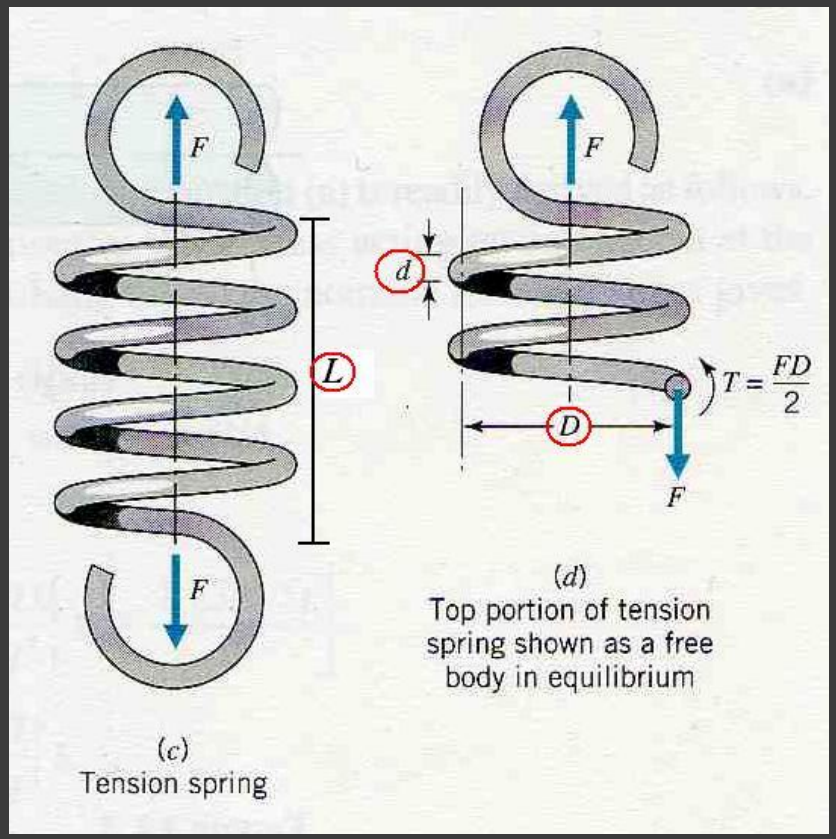
2. Data and Information Collection

- 스프링의 기본 형상



D : mean coil diameter
d : wire diameter
L : length (20cm)

Spring index $C = \frac{D}{d} \geq 3$

Force $F = \frac{100 \times 9.8}{20} = 49N$

2. Data and Information Collection

- ASTM 239 wire

$$G = 79GPa$$

$$\tau_{allow} = 0.45S_u = 0.45 \times 225ksi$$

$$= 0.45 \times 225 \times 6.89MPa$$

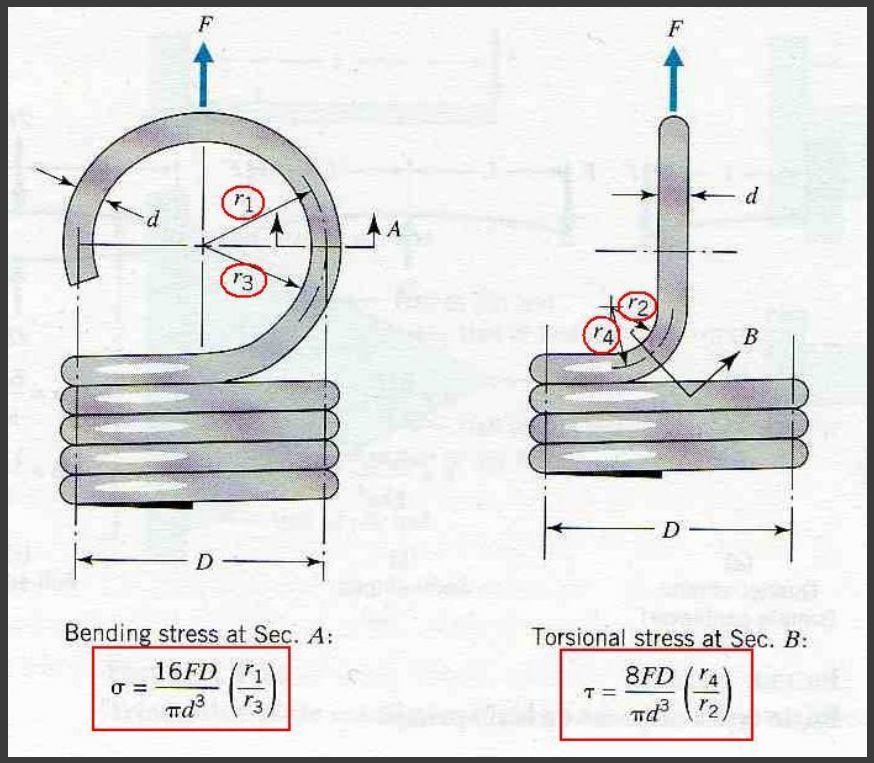
$$= \mathbf{697.613MPa}$$

$$\sigma_{allow} = 0.5S_u = 0.5 \times 225ksi$$

$$= 0.5 \times 225 \times 6.89MPa$$

$$= \mathbf{775.125MPa}$$

2. Data and Information Collection



$$r_1 = \frac{D}{2}, \quad r_3 = \frac{1}{2}(D-d)$$

$$r_4 = 2.5d\,(recommended), \quad r_2 = 2.5d - \frac{d}{2} = 2d$$

변형되는 길이

$$\delta = \frac{8FD^3N}{d^4G} = \frac{8FD^3L}{d^5G} \le 0.1(m)$$

Spring 끝 쪽에서 발생하는 응력

$$\sigma = \frac{16FD}{\pi d^3}\left(\frac{r_1}{r_3}\right)$$

$$\tau = \frac{8FD}{\pi d^3}\left(\frac{r_4}{r_2}\right)$$

Coil 내에서 발생하는 응력

$$\tau = \frac{8FD}{\pi d^3}\left(1+\frac{0.5}{C}\right) \le \tau_{initial}$$

$$\tau_{initial} = 0.4\frac{S_u}{C}$$

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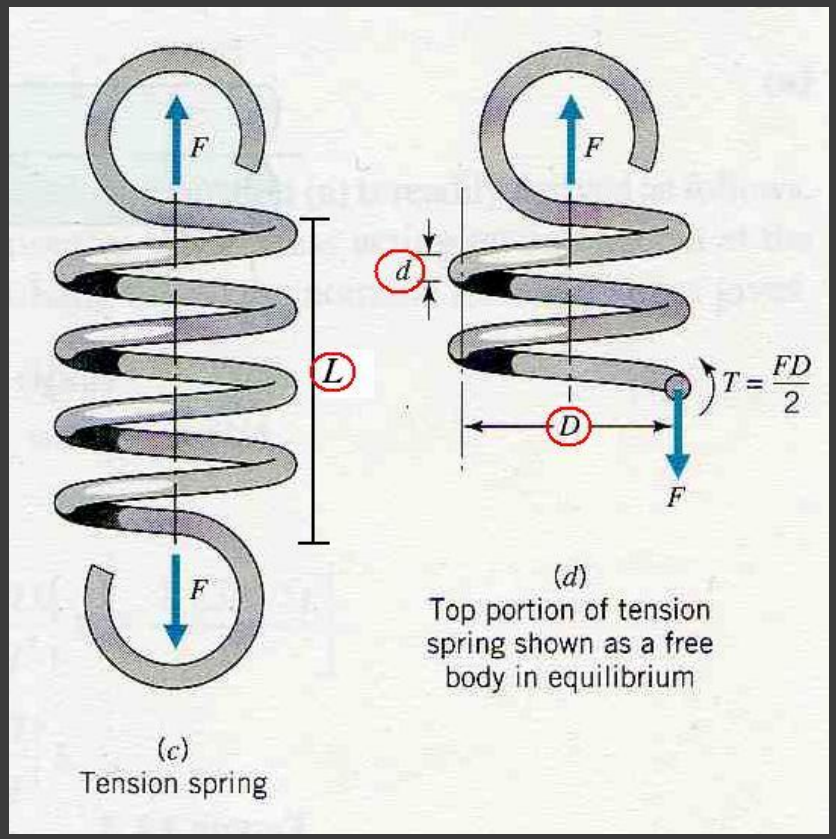
3. Identification of Design Variables

- 스프링의 기본 형상



D : mean coil diameter

d : wire diameter

단위 : m

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4. Identification of a Criterion to be Optimized

- Cost function

용수철 부피 최소화(재료의 양 최소화)

$$f(D,d) = \frac{\pi}{4} d^2 \times \pi D \frac{L}{d} = \frac{\pi^2}{4} DdL$$

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5. Identification of Constraints

$$C = \frac{D}{d} \geq 3$$

$$\delta = \frac{8FD^3L}{d^5G} \leq 0.1$$

$$\sigma = \frac{16FD}{\pi d^3}\left(\frac{D}{D-d}\right) \leq \sigma_{allow}$$

$$\tau = \frac{8FD}{\pi d^3}\left(\frac{2.5d}{2d}\right) \leq \tau_{allow}$$

$$\tau = \frac{8FD}{\pi d^3}\left(1+\frac{0.5}{C}\right) \leq \tau_{initial}$$

$$g_1 : 3d - D \leq 0$$

$$g_2 : \frac{8FD^3L}{d^5G} - 0.1 \leq 0$$

$$g_3 : \frac{16FD}{\pi d^3}\left(\frac{D}{D-d}\right) - \sigma_{allow} \leq 0$$

$$g_4 : \frac{10FD}{\pi d^3} - \tau_{allow} \leq 0$$

$$g_5 : \frac{8FD}{\pi d^3}\left(1+\frac{0.5}{C}\right) - \tau_{initial} \leq 0$$

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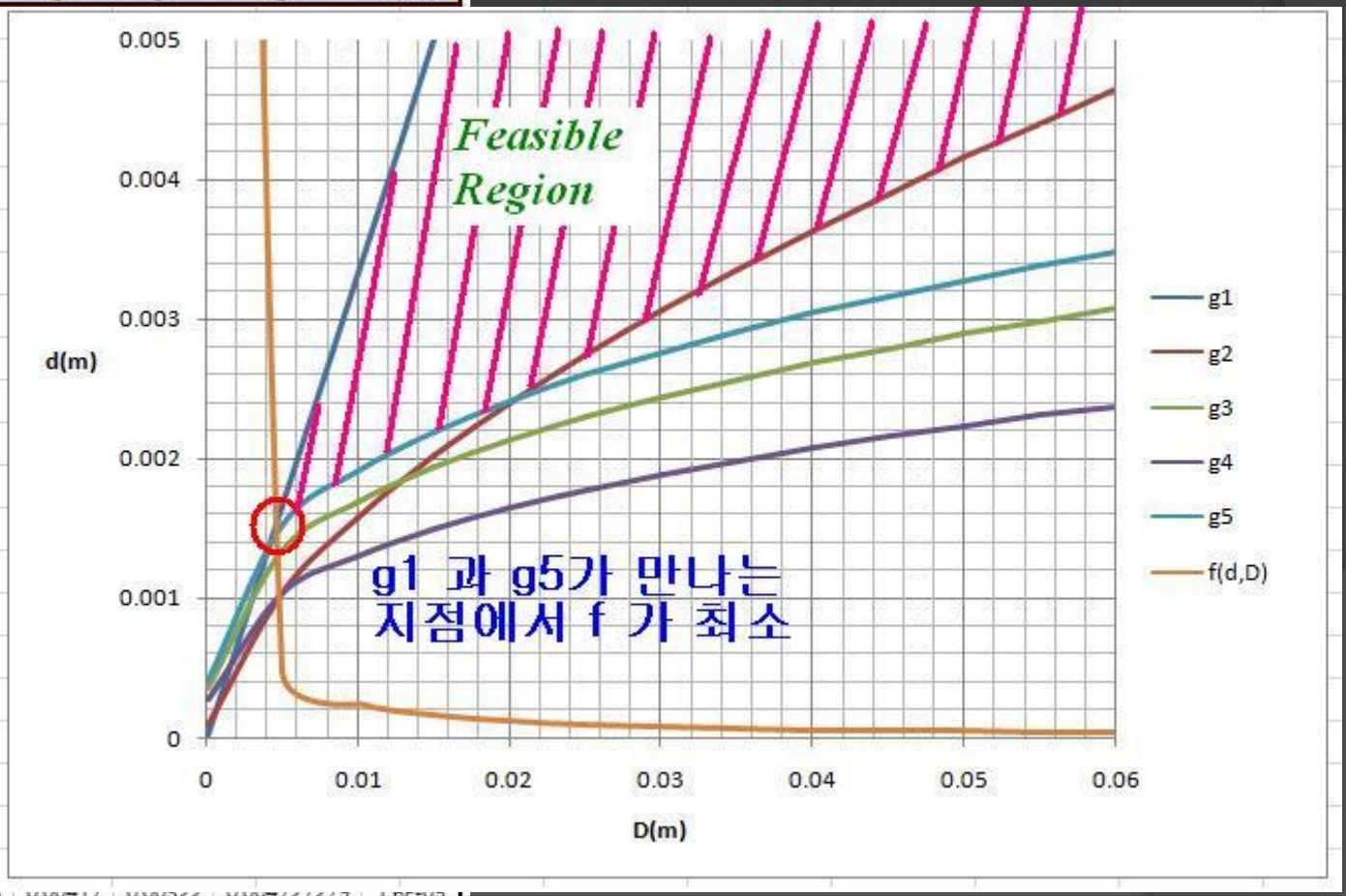
- 결과 표 & 그래프

D	g1	g2	g3	g4	g5	f(d,D)
0.0001	3.3E-05	9.98476E-05				
0.005	0.00167	0.00104404				
0.01	0.00333	0.00158247				
0.015	0.005	0.00201833				
0.02	0.00667	0.00239858				
0.025	0.00833	0.00274221				
0.03	0.01	0.00305921				
0.035	0.01167	0.00335566				
0.04	0.01333	0.00363558				
0.045	0.015	0.00390180				
0.05	0.01667	0.00415642				
0.055	0.01833	0.00440104				
0.06	0.02	0.00463690				
0.065	0.02167	0.00486503				
0.07	0.02333	0.00508623				
0.075	0.025	0.00530120				
0.08	0.02667	0.00551051				
0.085	0.02833	0.00571464				
0.09	0.03	0.00591402				
0.095	0.03167	0.00610902				
0.1	0.03333	0.00629996				
0.105	0.035	0.00648711				
0.11	0.03667	0.00667073				
0.115	0.03833	0.00685104				
0.12	0.04	0.00702823				
0.125	0.04167	0.00720250				
0.13	0.04333	0.00737401				
0.135	0.045	0.00754289				
0.14	0.04667	0.00770929				
0.145	0.04833	0.00787333				
0.15	0.05	0.00803512				



6. Simplified Solution

- Matlab Solver

```
1   %메틀랩 solve를 이용해서 g1과 g5 의 교점을 찾는다.
2 - [D] = solve('D/3 = (8*(100*9.8/20)*D*(1+0.5/3)/(0.4*225*pi*6.89*(10^6)/3))^(1/3)')
3   %D = .43606691333724466263061411286085e-2;
4   %d = .14535563777908155421020470428695e-2;
5   % D와 d 값을 위의 값으로 선택한 다음 목적함수값을 구한다.
6 - f= ((pi^2)/4)*D*d*0.2
7   %f = 3.1279e-006
```

D = 0.0043m = 4.3 mm

d =0.0014m = 1.4 mm

f= 3.128*10^(-6) m^3

Reference

- Robert C. Juvinall and Kurt M. Marshek , WILEY, “Fundamentals of Machine Component Design 4th Edition” - Ch12

- Jasbir S. Arora, Elsevier, “ Introduction to Optimum Design”

- 질문 있으세요?