

최적설계term project 최종발표

자전거 브레이크 고정장치의 비용절감

불 새

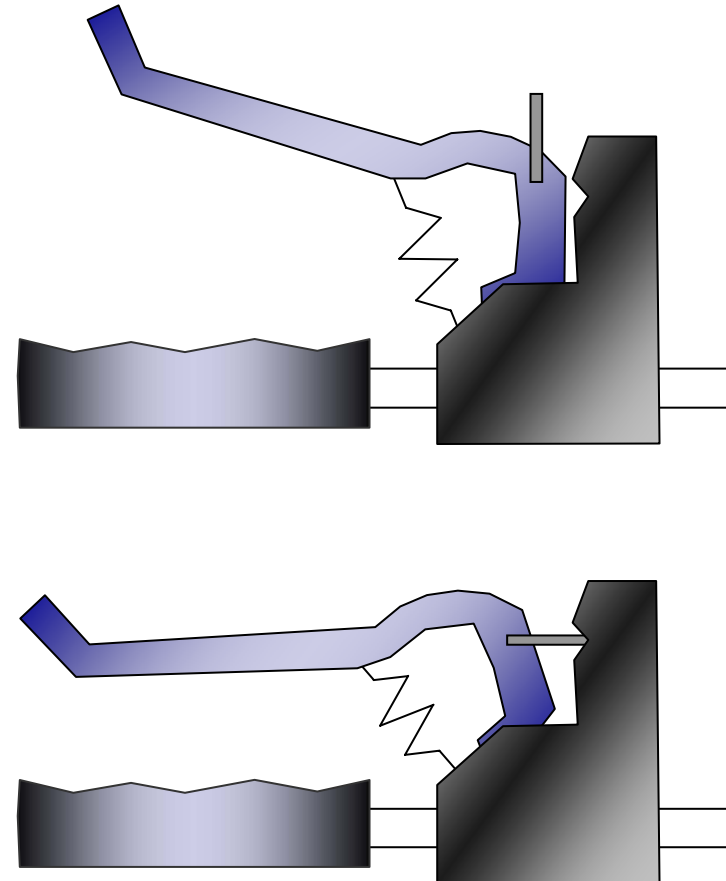
2002006844 윤지호

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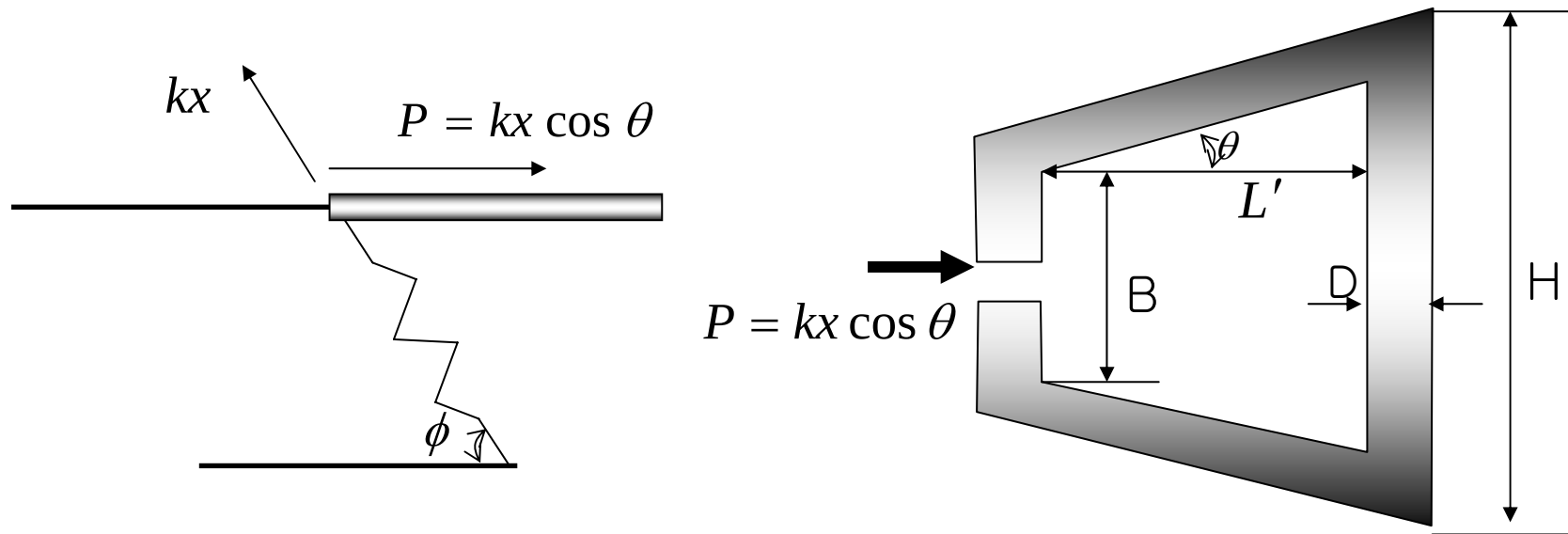
2002007676 정용환

1. Problem statement

- 자전거를 언덕이나 비탈진 곳에 세워놓을 경우 바퀴가 고정되어 있지 않기 때문에 미끄러져 내려가거나 넘어지는 상황이 발생하게 된다.
- 이를 방지하기 위하여 고안된 것이 자전거 브레이크 고정장치이다. 이에 티타늄을 이용하여 최소의 비용을 만족하는 직경과 핀의 각도를 구한다.



2.Data and Information Collection



- C : 주철의 단위 질량당 가격
- F.S : 안전계수 (Factor of Safety)
- E : Young's Modulus
- L' : 1.5cm
- B : 1cm
- ϕ : 60°



3.Design Variables

- 고정장치의 직경 : D
- 고정장치의 각도 : θ

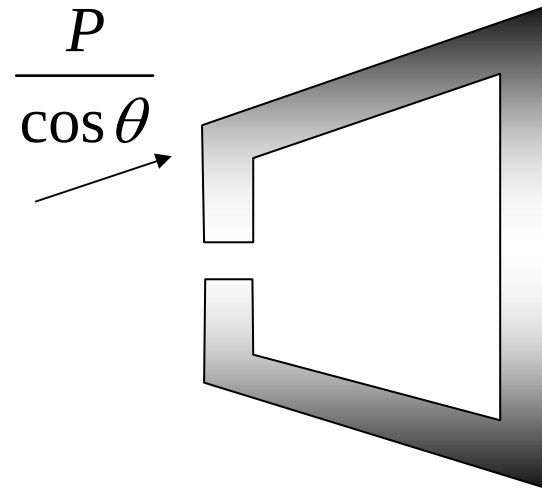
4.Cost Function

- $$f(D, \theta) = C\rho \frac{\pi D^2}{2} \left(B + \frac{L'}{\cos \theta} + L' \tan \theta \right)$$

5.Constraints

■ g1(압축응력)

$$F.S \frac{P}{A} = F.S \frac{P / \cos \theta}{\frac{\pi D^2}{4}} \leq \sigma_Y$$

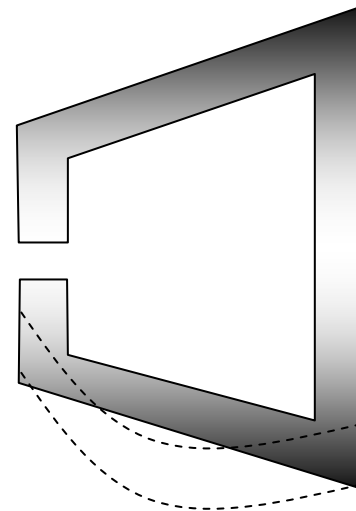


■ g2(좌굴하중)

$$P_{cr} = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 E \frac{\pi}{64} D^4}{\left(\frac{L'}{\cos \theta}\right)^2}$$

$$\frac{P_{cr}}{A} = \sigma_{cr}$$

$$F.S \cdot \sigma_{cr} \leq \sigma_Y$$

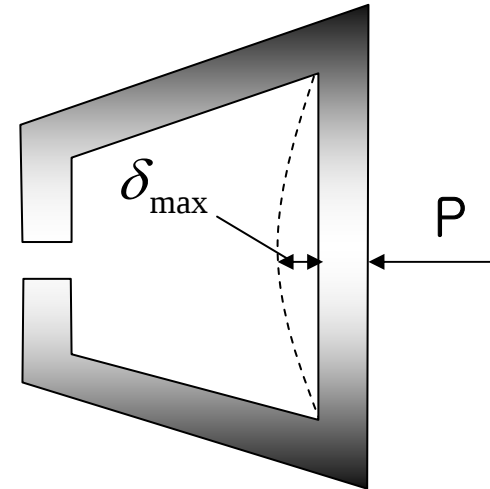


■ g3(처짐)

$$\frac{1}{2}H = \frac{1}{2}(B + 2L' \tan \theta) \quad x = \frac{1}{2}H$$

$$y = \frac{P}{48EI}(4x^3 - 3L^2x)$$

$$\delta_{\max} = \frac{P}{48EI} \left[4\left(\frac{1}{2}H\right)^3 - 3H^2\left(\frac{1}{2}H\right) \right] \leq 1 \text{ mm}$$



■ g4(직경)

$$1 \text{ mm} \leq D \leq 5 \text{ mm}$$

■ g5(각도)

$$5^\circ \leq \theta \leq 25^\circ$$

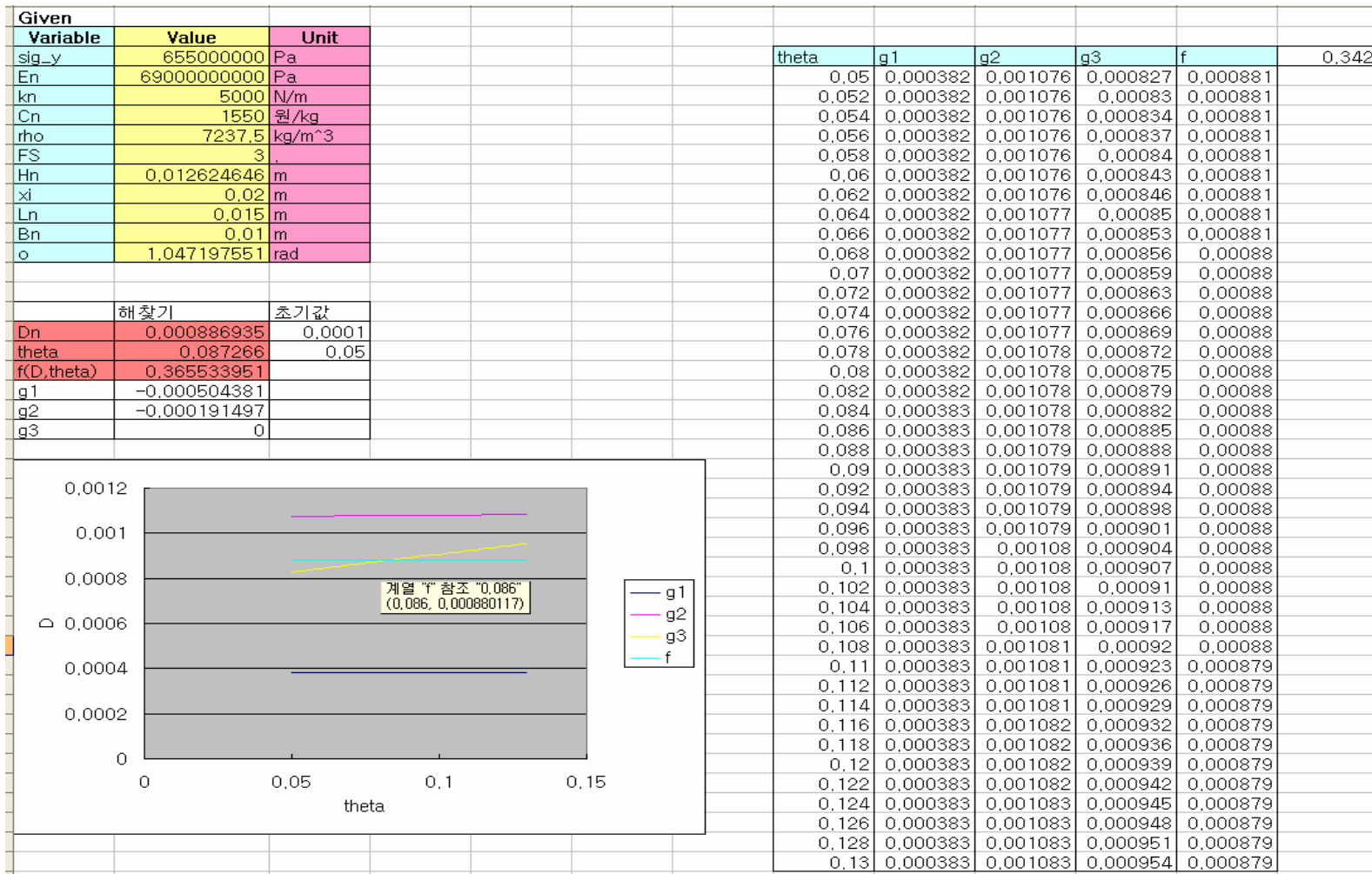


6. 최적화결과

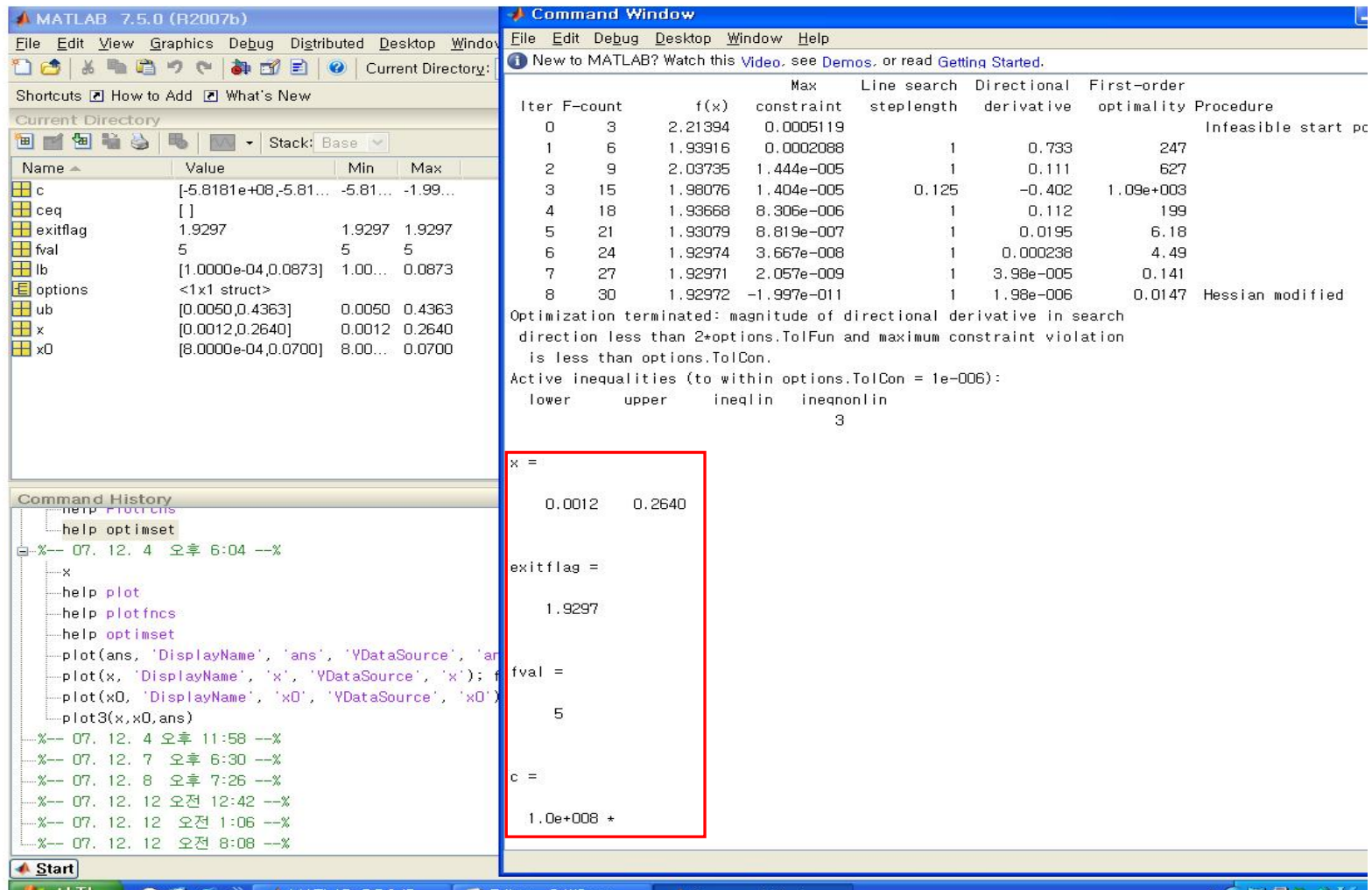
■ 가정한 상수

- $\sigma_Y = 655 \times 10^6 \text{ Pa}$
- $E = 69 \times 10^9 \text{ Pa}$
- $k = 5 \text{ kN / m}$
- $C = 1550 \text{ 원/kg}$
- $\rho = 71000 \text{ N/m}^3$
- $F \cdot S = 3$
- $H = 0.02 \text{ m}$
- $t = 0.02 \text{ m}$
- $L' = 0.015 \text{ m}$
- $B = 0.01$
- $\phi = 60^\circ$

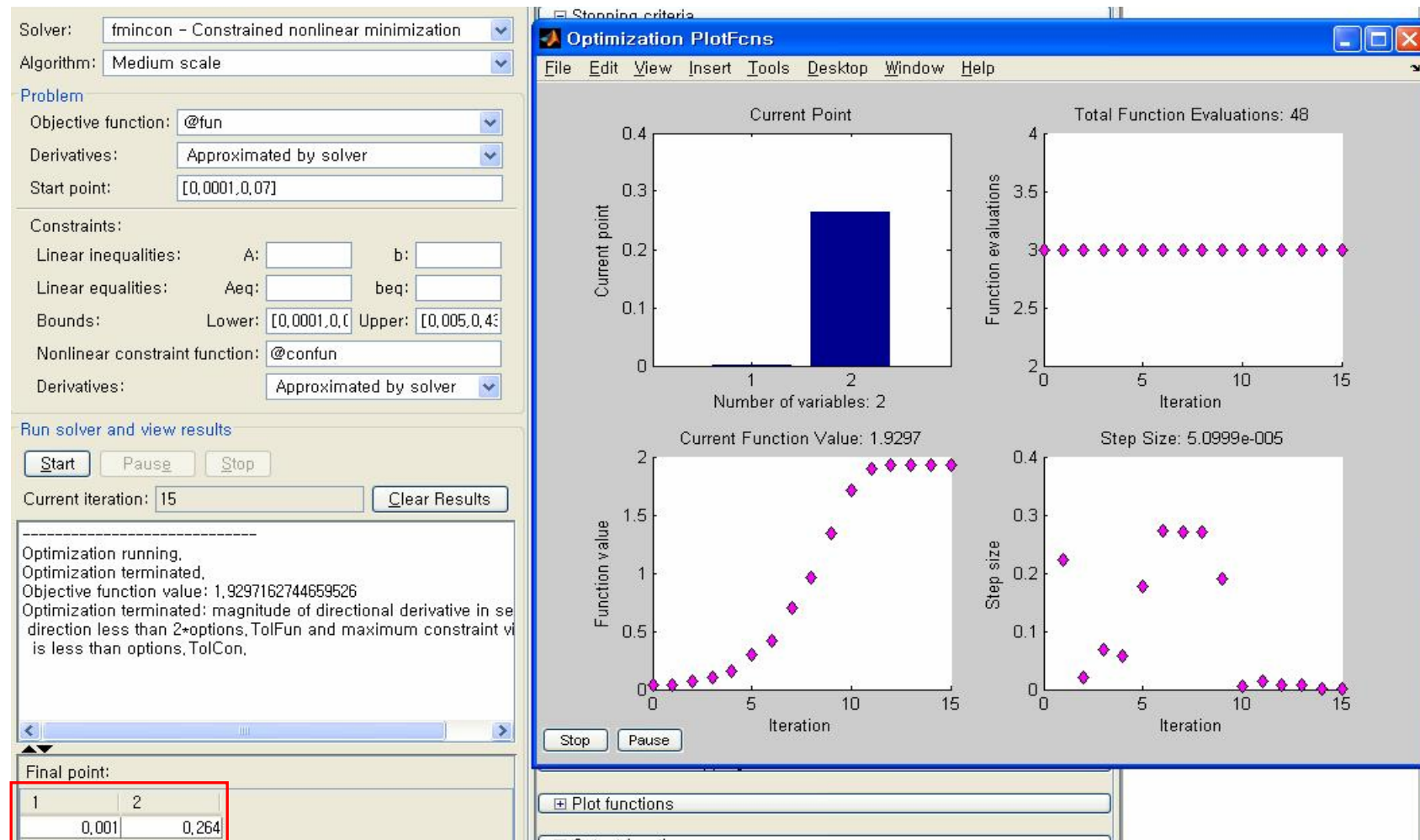
■ Graphical method & Excel solver



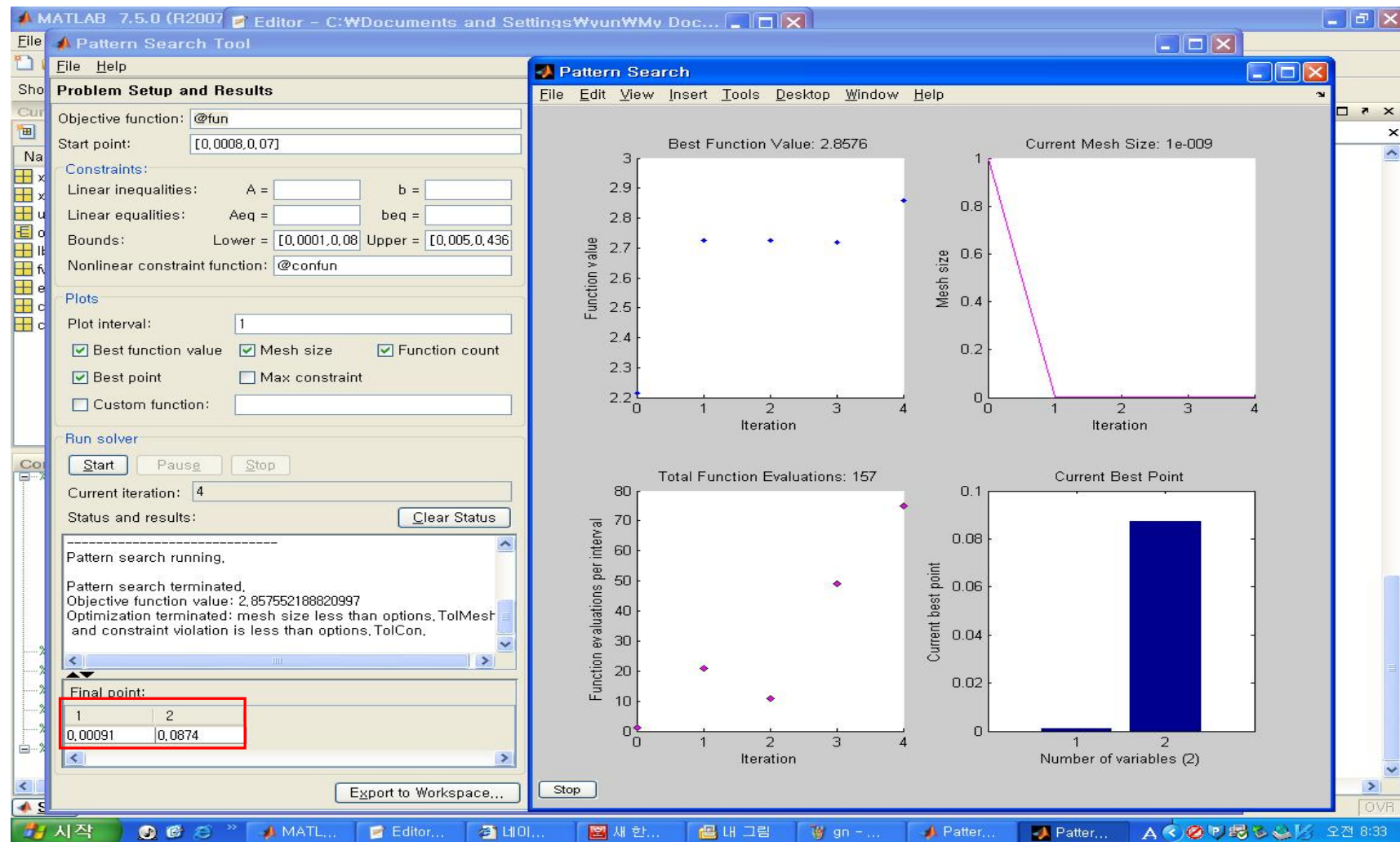
■ MATLAB fmincon



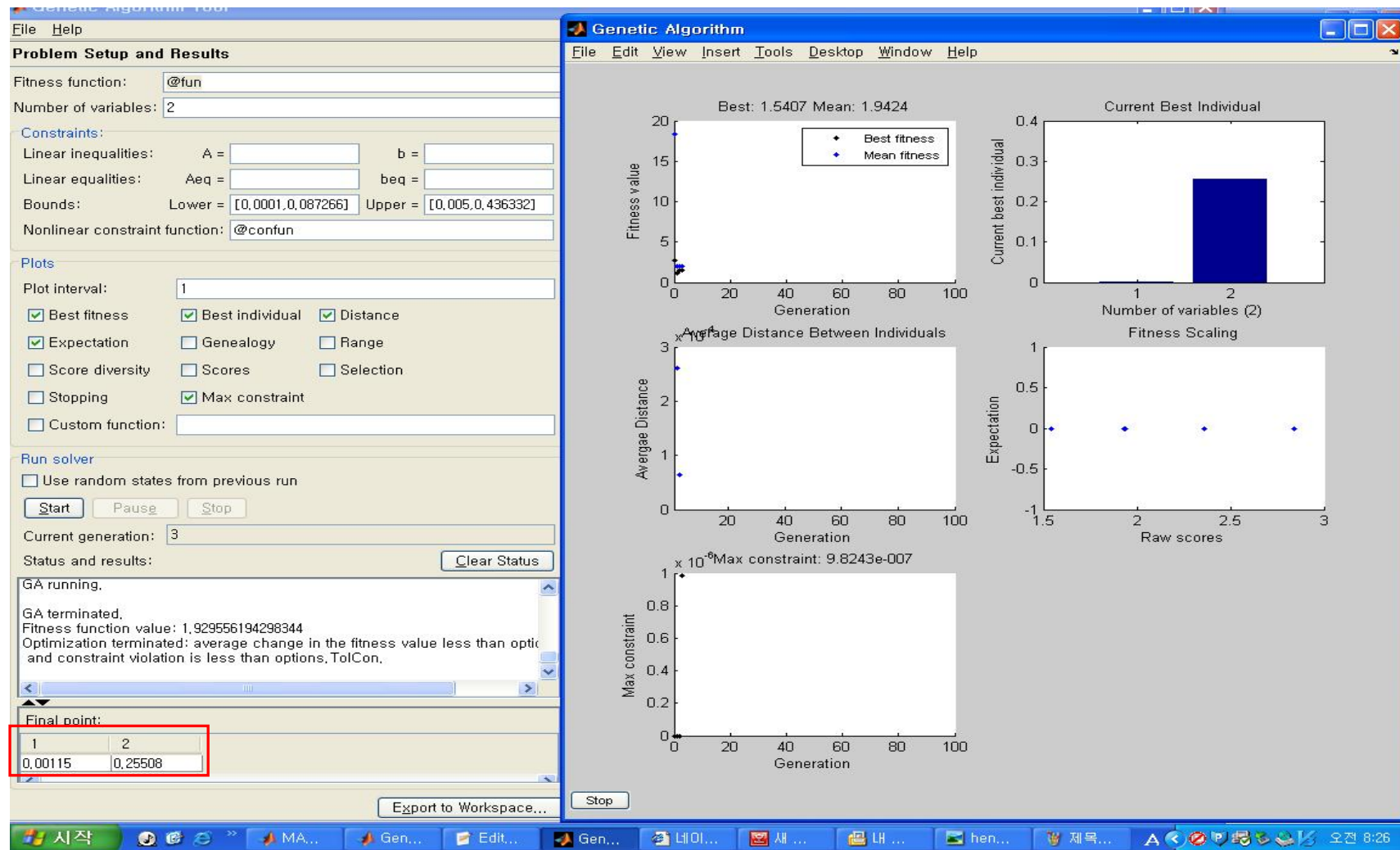
■ MATLAB fmincon GUI



■ MATLAB Pattern Search Tool



■ MATLAB Genetic algorithms

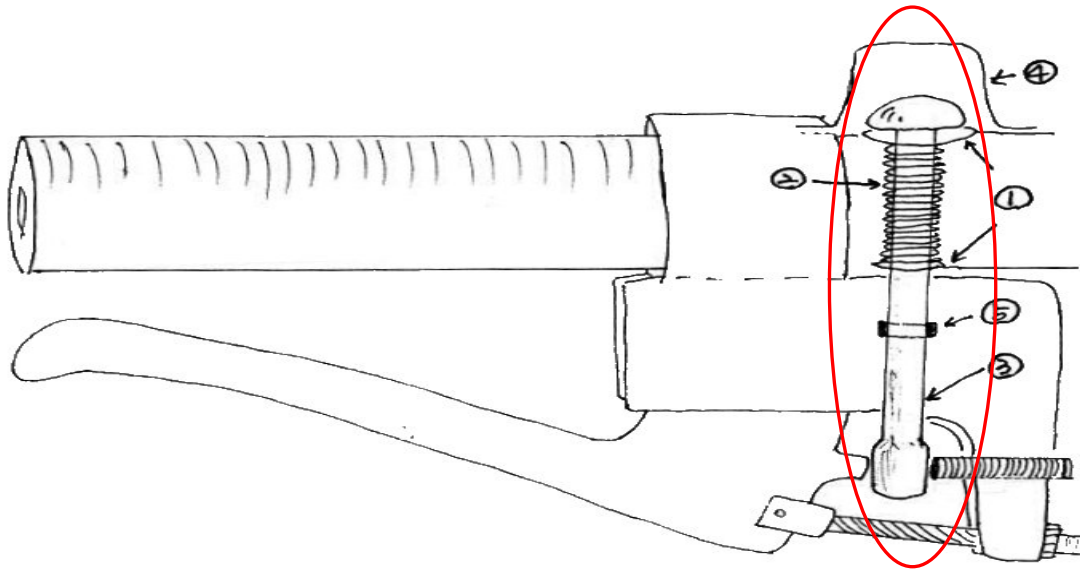




■ 최적해

- $D : 0.87 \text{ mm}$
- $\theta : 5^\circ$
- Cost : 0.36 원

7. 기존설계와 비교



$$\begin{aligned}\blacksquare \text{핀비용} &= c\rho\frac{\pi}{4}D^2l \\ &= (1550)(71)\frac{\pi}{4}(0.01)(0.06) \\ &= 0.5\text{원}\end{aligned}$$

c : kg당 가격

ρ : 주철밀도

D : 핀의직경

l : 핀의길이