Company
LOGO

청소를 편하게

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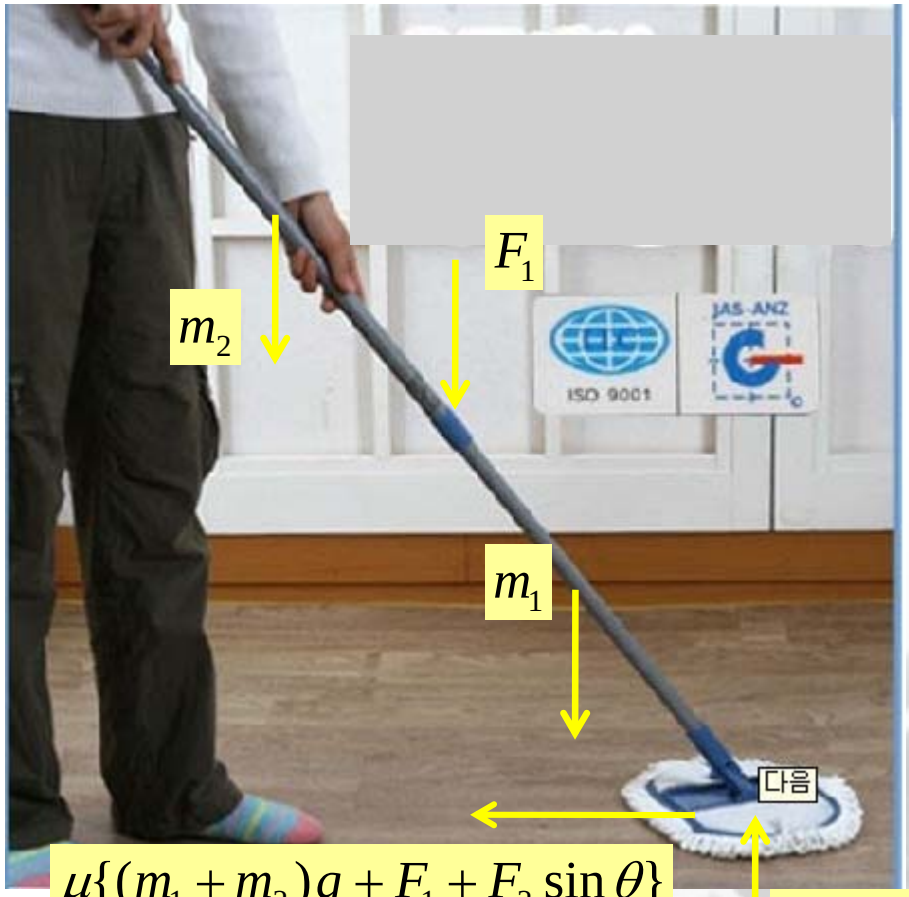
- Statement 및 기존설계 Review
- Data 및 목적함수와 Consatraint
- 최적화

Statement

걸레의 대의 재료가 될 수 있는 재료는 3가지이다. 대가 사용되는 조건은 스스로 정하고 변수 값은 두 개의 대의 반지름과 두께로 하라. 걸레의 수명은 무한이 되도록 하고 대의 질량을 최소화 할 수 있도록 최적의 변수들을 설계한 후 재료를 선정하고 그 질량을 구해라.

기존 프로젝트


F_2
F_1
m_2
m_1
ISO 9001
JAS-ANZ
다음
$\mu\{(m_1+m_2)g+F_1+F_2\sin\theta\}$
$F_1+F_2\sin\theta+(m_1+m_2)g$

1번에 작용하는 힘

$$F_1, F_2, \mu\{(m_1+m_2)g+F_1+F_2\sin\theta\}, M$$

$$\sigma_1 = \frac{\sqrt{[\mu\{(m_1+m_2)g+F_1+F_2\sin\theta\}]^2+{F_2}^2\sin^2\theta}+F_1\sin\theta}{A_1}$$

$$\sigma_2 = \frac{Mc}{I} \qquad I = \frac{\pi R^3 t}{4}$$

$$\therefore \sigma_1+\sigma_2 \le \sigma_a$$

$$\frac{\sqrt{[\mu\{(m_1+m_2)g+F_1+F_2\sin\theta\}]^2+{F_2}^2\sin^2\theta}+F_1\sin\theta}{A_1}+\frac{Mc}{I} \le \sigma_a$$

2번에 작용하는 힘

F_2, M

$$\sigma_3 = \frac{\sqrt{[\mu\{(m_1+m_2)g + F_1 + F_2\sin\theta\}]^2 + {F_2}^2\sin^2\theta}}{A_2}$$

$$\sigma_4 = \frac{Mc}{I}$$

$$\therefore \sigma_1 + \sigma_2 \le \sigma_a$$

$$\frac{\sqrt{[\mu\{(m_1+m_2)g + F_1 + F_2\sin\theta\}]^2 + {F_2}^2\sin^2\theta}}{A_2} + \frac{Mc}{I} \le \sigma_a$$

X'방향 변형

$$\delta = \frac{PL}{AE}$$

가운데점

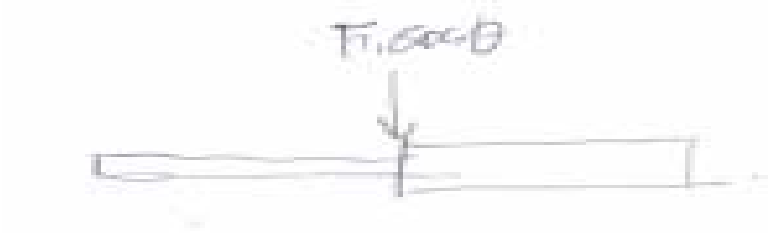
$$F_1 \sin\theta + F_2 - \mu\{(m_1 + m_2)g + F_1 + F_2 \sin\theta\} = P$$

2번이 늘어난 길이=1번이 줄어든 길이

$$\frac{PL}{A_2E_2} = \frac{PL}{A_1E_1} \Longrightarrow \text{같은재질} E_2 = E_1$$

$A_2 = A_1$일수밖에없다. ==>두값이매우작아서무시할만함

Y'방향 변형



$$EIy'''' = -F_1 \cos\theta < x - L >^{-1}$$

$$EIy''' = -F_1 \cos\theta < x - L >^{0} + C_1$$

$$EIy'' = -F_1 \cos\theta < x - L >^{1} + C_1 x + C_2$$

$$EIy' = -\frac{1}{2} F_1 \cos\theta < x - L >^{2} + \frac{1}{2} C_1 x^2 + C_2 x + C_3$$

$$EIy = -\frac{1}{6} F_1 \cos\theta < x - L >^{3} + \frac{1}{6} C_1 x^3 + \frac{1}{2} C_2 x^2 + C_3 x + C_4$$

BoundaryConditions

$$y(0) = 0$$

$$y(2L) = 0$$

$$M(0) = EIy''(0) = 0$$

$$M(2L) = EIy''(2L) = 0$$

$$\frac{1}{EI}\left(\frac{1}{6} L^3 F_1 \cos\theta\right) \le y_{\max}$$

전단응력

1번에작용하는전단응력

$$\frac{F_1\cos\theta-\mu\{(m_1+m_2)g+F_1+F_2\sin\theta)\sin\theta}{A_1}\le\tau_a$$

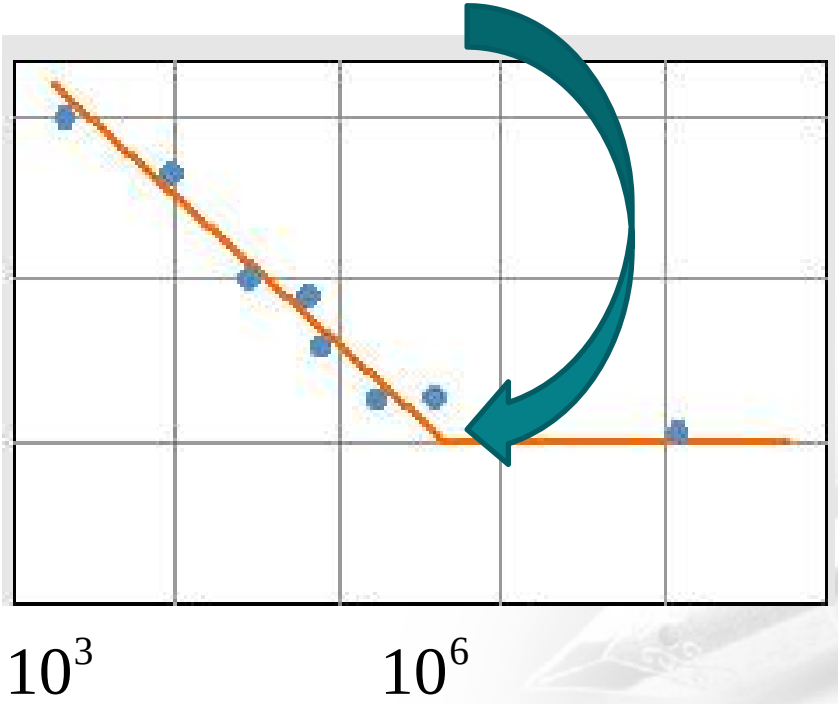
2번에작용하는전단응력

$$\frac{F_1\cos\theta-\mu\{(m_1+m_2)g+F_1+F_2\sin\theta)\sin\theta}{A_2}\le\tau_a$$

수명

$S-N$ Curve

$$S_n = S_n' C_L C_G C_S C_T C_R$$



Steel 물성치

	밀도 (kg/m³)	σa(Mpa)	τa(MPa)	E(Gpa)
Steel	7860	250	145	200

$$S_n = S_n' C_L C_G C_S C_T C_R$$

- $S_n' = 0.5 S_u$ (steel)
- $C_L = 0.58$ (*torsion*)
- $C_G = 0.8$ (*diameter* 관련)
- $C_S = 1$ (*surface factor*)
- $C_T = 1$ ($T \le 840\ ^\circ F$)
- $C_R = 0.753$ (*reliabilit y factor* 99.9%)

$$\sigma_a = 75.3 MPa$$

$$\tau_a = 25.3309 MPa$$

Alloy 2014 – T6 물성치

	밀도 (kg/m³)	σa(Mpa)	τa(MPa)	E(Gpa)
Alloy 2014-T6	2800	400	230	75

$$S_n = S_n' C_L C_G C_S C_T C_R$$

$S_n' = 0.5 S_u$

$C_L = 0.58$ (*torsion*)

$C_G = 0.8$ (*diameter* 관련)

$C_S = 1$ (*surface factor*)

$C_T = 1$ ($T \le 840\ ^\circ F$)

$C_R = 0.753$ (*reliabilit y factor* 99 .9%)

$$\sigma_a = 120.48 MPa$$

$$\tau_a = 40.1801 MPa$$

Yellow brass 물성치

	밀도 (kg/m³)	σa(Mpa)	τa(MPa)	E(Gpa)
Yellow brass	8470	410	250	105

$$S_n = S_n' C_L C_G C_S C_T C_R$$

$S_n' = 0.5 S_u$

$C_L = 0.58$ (*torsion*)

$C_G = 0.8$ (*diameter* 관련)

$C_S = 1$ (*surface factor*)

$C_T = 1$ ($T \le 840\ ^\circ F$)

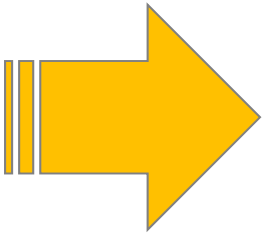
$C_R = 0.753$ (*reliabilit y factor* 99 .9%)

$$\sigma_a = 123.492 MPa$$

$$\tau_a = 43.674 MPa$$

$$m_1 = 2\pi r_1 t_1 L\rho$$

$$m_2 = 2\pi r_2 t_2 L\rho$$



m_1, m_2 가 r, t와 종속

m_1, m_2 무시

1번

$$\frac{\sqrt{[\mu\{F_1 + F_2 \sin\theta\}]^2 + {F_2}^2 \sin^2\theta} + F_1 \sin\theta}{A_1} + \frac{Mc}{I} \le \sigma_a$$

$$\frac{F_1 \cos\theta - \mu(F_1 + F_2 \sin\theta)\sin\theta}{A_1} \le \tau_a$$

$$EIy'' = -F_1 \cos\theta < x - L >^1 + C_1 x + C_2$$

$$\Rightarrow M = -F_1 \cos\theta < x - L >^1 + \frac{F_1 \cos\theta}{2} x$$

$$M(L) = \frac{F_1 \cos\theta}{2} L$$

2번

$$\frac{\sqrt{[\mu\{F_1 + F_2 \sin\theta\}]^2 + {F_2}^2 \sin^2\theta}}{A_2} + \frac{Mc}{I} \le \sigma_a$$

$$\frac{F_1 \cos\theta - \mu(F_1 + F_2 \sin\theta)\sin\theta}{A_2} \le \tau_a$$

Parameters

보통 대의 길이
120~140(cm) 사이

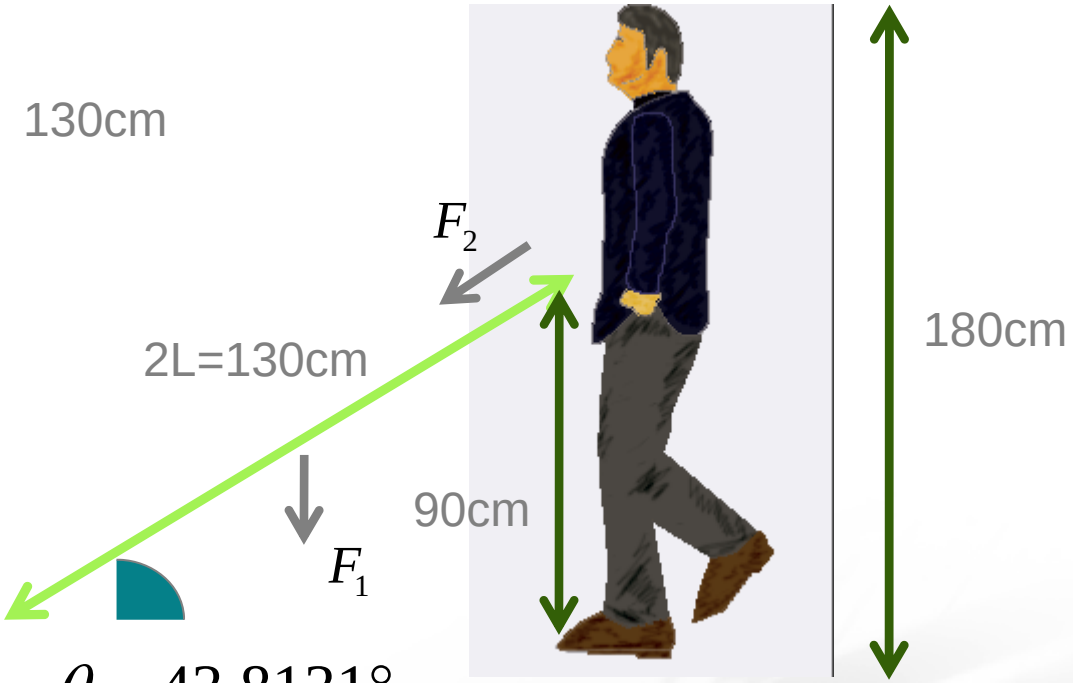
130cm

$F_1 = 200N$

$F_2 = 100N$

$g = 9.81m/s^2$

$\mu_k = 0.3$



$\theta = 43.8131°$

$40°$

Design Variables

r_1 t_1

r_2 t_2

r_1 t_1에 종속적

목적함수

큰 목적함수

$$f = 2\pi(r_1 t_1 + r_2 t_2)L\rho = m$$

r_1, t_1구하면r_2, t_2알수있다.

$\therefore f = 2\pi r_1 t_1 L$(1번쪽이상대적으로더큰 힘을 받음)

Constraint

$$1: \frac{36.7050}{r_1 t_1} + \frac{63.3983}{r_1^2 t_1} \le \sigma_a$$

$$2: \frac{16.2730}{r_1 t_1} \le \tau_a$$

$$3: \frac{16.2445}{r_2 t_2} + \frac{63.3983}{r_2^2 t_2} \le \sigma_a$$

$$4: \frac{16.2730}{r_2 t_2} \le \tau_a$$

$$5: \frac{8.0286}{E r_1^3 t_1} \le y_{\max}(0.001m)$$

$$6: \frac{8.0286}{E r_2^3 t_2} \le y_{\max}$$

$$7: 0.01 \le r \le 0.05(m)$$

$$8: 0.0001 \le t \le 0.05(m)$$

Solver(1)

기존 것과 비슷한 결과(여러가지 상황이 다르긴 하지만 나온 결과값은 대충 비슷)

E1	2E+11			시그마	31983294.34	
E2				타우	162309.2692	
E3				y변형량	0.00100098	
	r1	0.02				
	t1	0.005012961				
	f	0.000409258			허용응력(시그마)	75300000
					허용응력(타우)	25330900
					ymax	0.001
0.01	r1	0.02				
0.0001	t1	0.1				

Solver

초기값(1, 1)

E1	2E+11			시그마	75300000	
E2				타우	891336.5806	
E3				y변형량	0.000979409	
	r1	0.047381612				
	t1	0.000385315				
	f	7.45245E-05			허용응력(시그마)	75300000
					허용응력(타우)	25330900
					ymax	0.001
0.01	r1	0.05				
0.0001	t1	0.05				

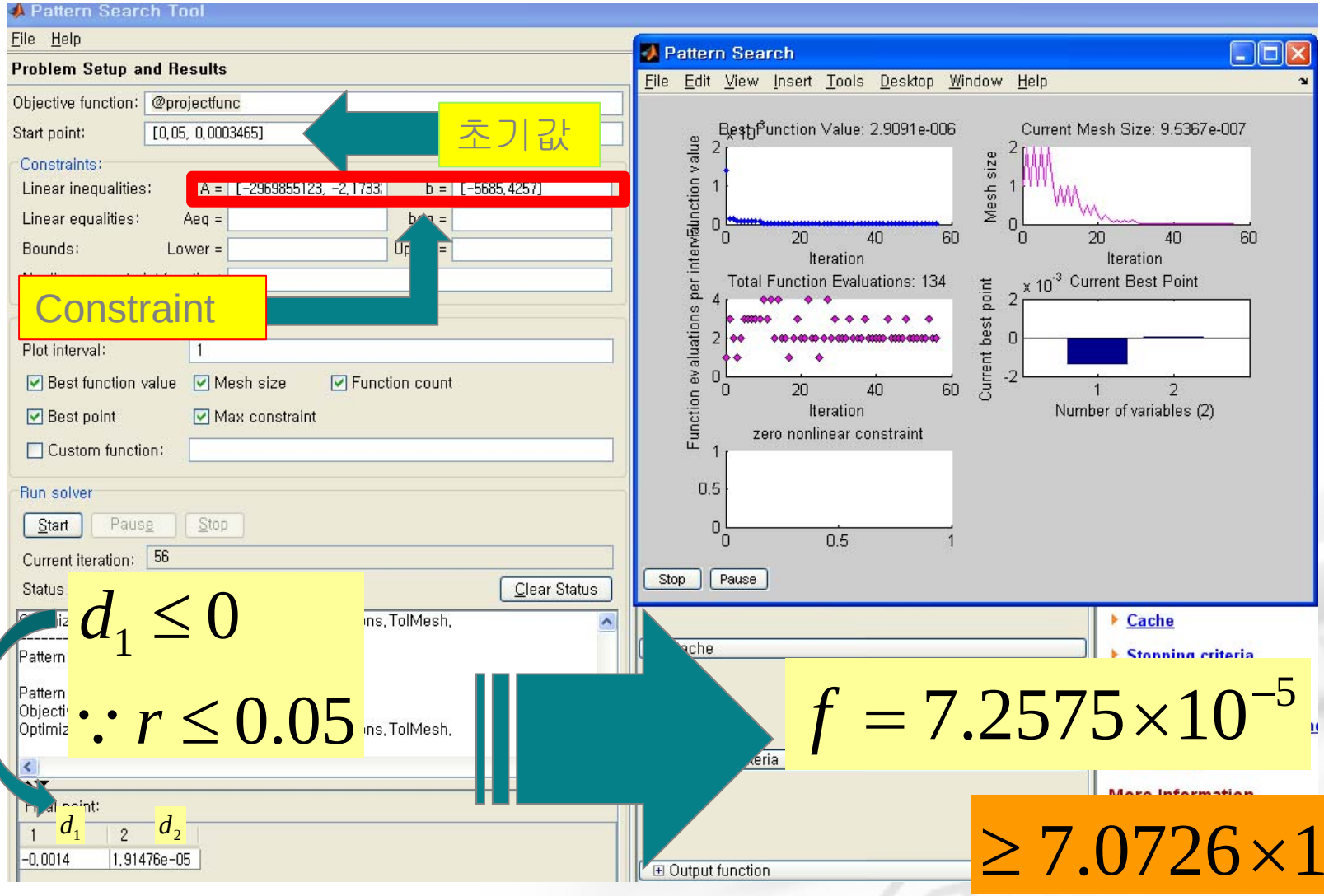
Solver

초기값 (0.1, 0.01), (0.03, 0.07), (0.03, 0.001)

E1	2E+11			시그마	75300000	
E2				타우	939207.5857	
E3				y변형량	0.000926753	
	r1	0.05				
	t1	0.000346526				
	f	7.0726E-05			허용응력(시그마)	75300000
					허용응력(타우)	25330900
					ymax	0.001
0.01	r1	0.05				
0.0001	t1	0.05				

QP

Pattern Search



$d_1 \le 0$

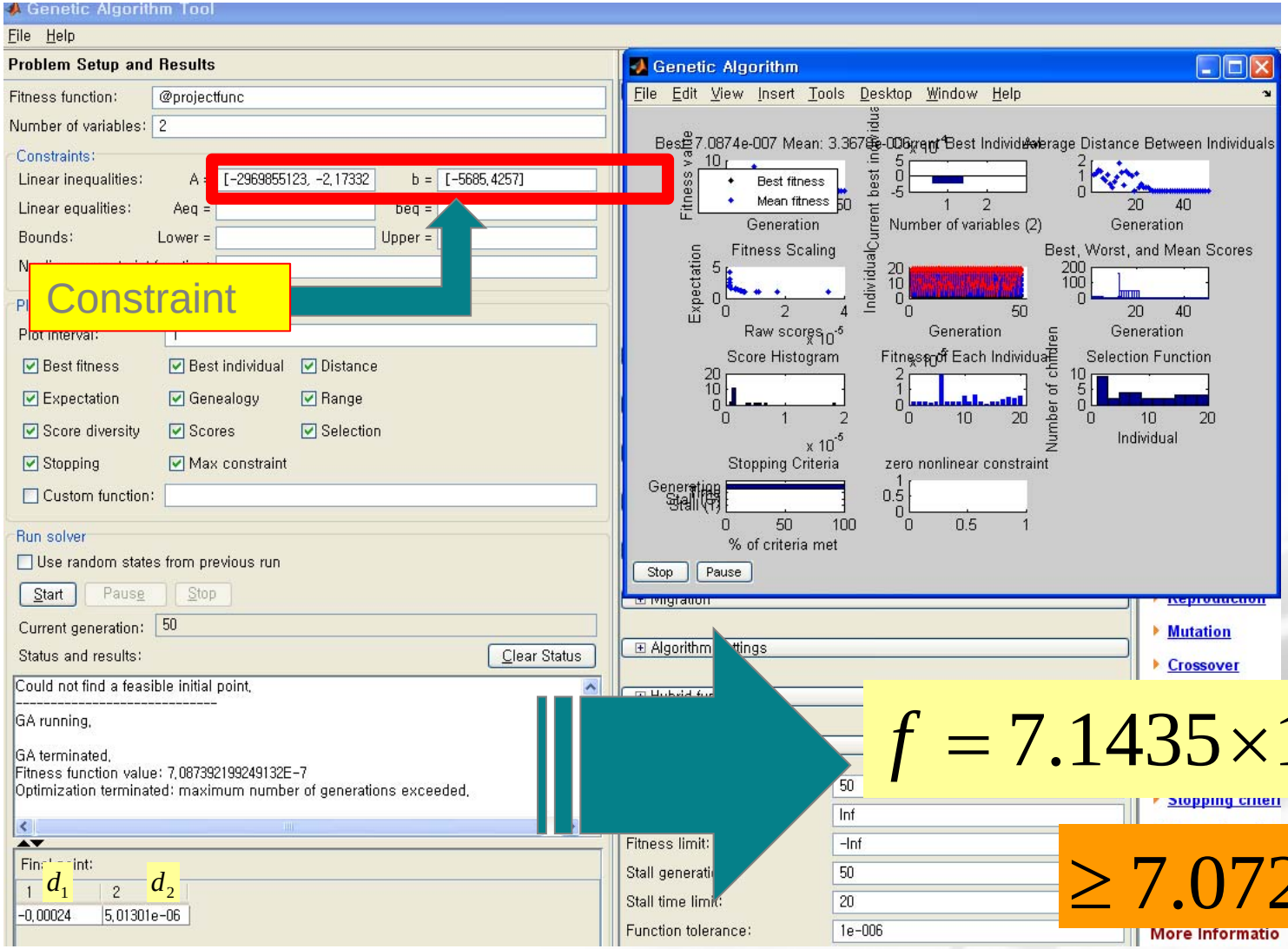
$\because r \le 0.05$

$f = 7.2575 \times 10^{-5}$

$\ge 7.0726 \times 10^{-5}$

QP

Genetic Algorithm(너무 불규칙)



d_1 d_2

$$f = 7.1435 \times 10^{-5}$$

$$\geq 7.0726 \times 10^{-5}$$

Steel

결과값

$r_1 = 0.05$

$t_1 = 0.0003465$

$r_2 = 0.0502$

$t_2 = 0.0003439$

$$m = 2\pi(r_1 t_1 + r_2 t_2)L\rho$$

$$= 1.1103kg$$

Solver(2)

초기값에 관계X

E1	2E+11			시그마	30481095.41	
E2	7.5E+10			타우	380186.9327	
E3	1.05E+11			y변형량	0.001000387	
	r1	0.05				
	t1	0.000856053				
	f	0.00017472			허용응력(시그마)	120480000
					허용응력(타우)	40180000
					ymax	0.001
0.01	r1	0.05				
0.0001	t1	0.05				

Alloy 2014 - T6

결과값

$r_1 = 0.05$

$t_1 = 0.0008566$

$r_2 = 0.0504$

$t_2 = 0.0002098$

$$m = 2\pi(r_1 t_1 + r_2 t_2)L\rho$$

$$= 0.6107kg$$

Solver(3)

초기값(1, 1)

E1	2E+11			시그마	42631752.04	
E2	7.5E+10			타우	531740.5698	
E3	1.05E+11			y변형량	0.000999408	
	r1	0.05				
	t1	0.000612065				
	f	0.000124923			허용응력(시그마)	123492000
					허용응력(타우)	43674000
					ymax	0.001
0.01	r1	0.05				
0.0001	t1	0.05				

Solver(3)

초기값(0.1, 0.001)

E1	2E+11			시그마	42618726.98	
E2	7.5E+10			타우	531578.1098	
E3	1.05E+11			y변형량	0.000999102	
	r1	0.05				
	t1	0.000612252				
	f	0.000124961			허용응력(시그마)	123492000
					허용응력(타우)	43674000
					ymax	0.001
0.01	r1	0.05				
0.0001	t1	0.05				

Solver(3)

초기값(0.03, 0.001)

E1	2E+11			시그마	42667759.75	
E2	7.5E+10			타우	532189.6895	
E3	1.05E+11			y변형량	0.001000252	
	r1	0.05				
	t1	0.000611549				
	f	0.000124817			허용응력(시그마)	123492000
					허용응력(타우)	43674000
					ymax	0.001
0.01	r1	0.05				
0.0001	t1	0.05				

Yellow brass

결과값

$r_1 = 0.05$

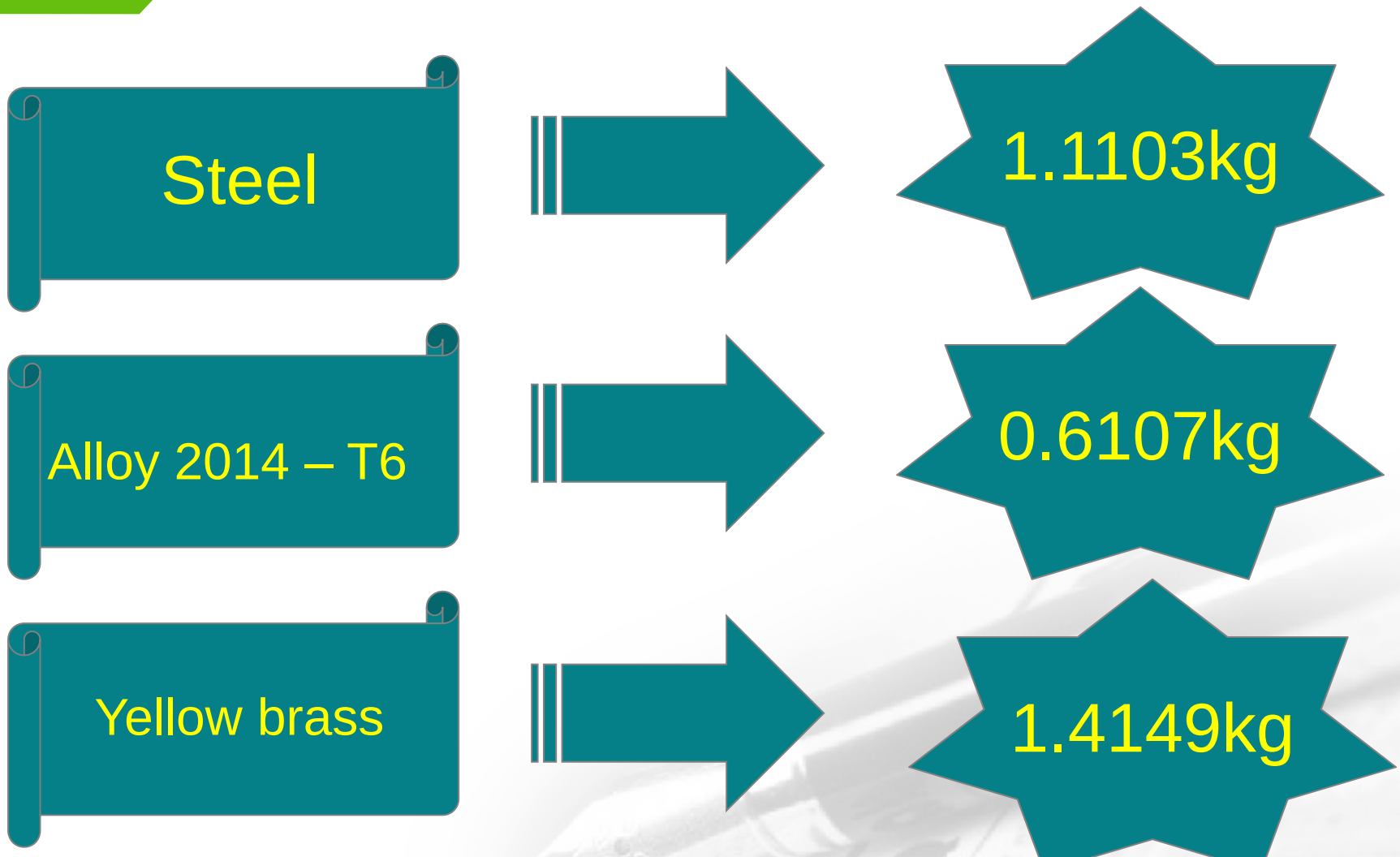
$t_1 = 0.0006116$

$$m = 2\pi(r_1 t_1 + r_2 t_2)L\rho$$
$$= 1.4149kg$$

$r_2 = 0.0504$

$t_2 = 0.0002048$

결과값 비교



결론

Alloy 2014 – T6

$r_1 = 0.05m$

$t_1 = 0.0008566m$

$r_2 = 0.0504m$

$t_2 = 0.0002098m$

0.6107kg

Q & A