Mechanical Engineering

OPTIMUM DESIGN

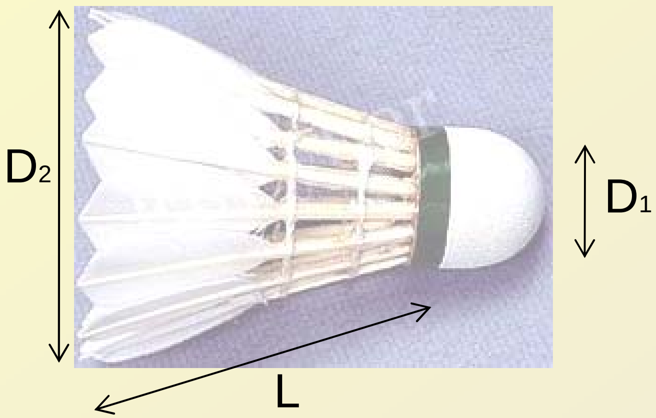
TEAM :METALIC COCK

Project/Problem statement

- 셔틀콕 1개 = 거위 3마리
- 현재의 셔틀콕은 깃털이 잘 부러짐 (배드민턴 1경기당 셔틀콕 20개 소비)

- 소재를 바꾸어 내구성 증가
- 금속재료를 선택하여 경량화가 관건
- 기본적 형상은 유지, 치수 보정

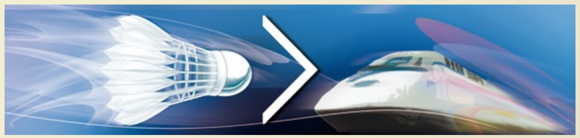
Data Collection



최대 직경(D_2): 6 cm
날개 부분 길이 : 7 cm
콕 부분 직경 : 3cm
셔틀콕의 총 중량: 5g

Data Collection

- Al 1100 $\begin{cases} \sigma_{allow} = 34 \text{ Mpa} \\ \rho = 2700 \text{ kg/m}^3 \end{cases}$
-
- Fd $= \dfrac{C_d A_p \rho V^2}{2}$



- V initial = 320 km/h
- V final = 60 km/h
- V average = 100 km/h

Data Collection

- Determine applied force (F)
- Momentum Eq.

$$mv_f + F\Delta t = mv_i$$

- Contact time

golf = 0.0005 sec

baseball = 0.0012 sec

$$\Delta t = 0.001\mathrm{sec} \quad F = 528N$$

Assumption

- 재료는 Homogeneous함
- Free-Free condition이므로 buckling은 일어나지 않음
- Cock은 symmetric
- Cock의 회전운동 무시
- 유체저항 계산시 corn의 모양으로 가정
- Cock의 중앙에 정확히 하중을 받음
- Thickness << D1

Design variable

- Outer diameter
- Thickness

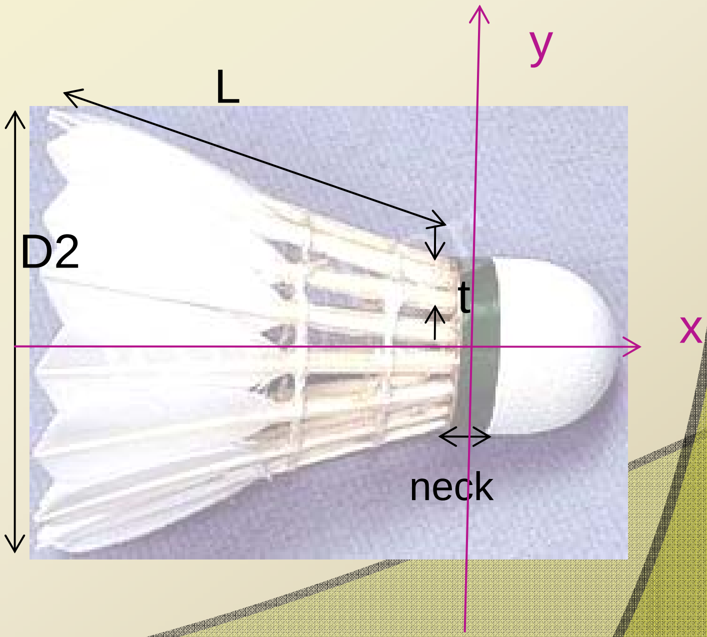
Objective function

- Minimize mass

  = Density×(Total volume)

$$= \rho(\pi\int y^2dx + \pi\frac{D_1^{\,2}}{4}l_{neck} + \frac{2}{3}\pi(\frac{D_1}{2})^3)$$

$y: equation\ of\ line\ \mathrm{L}$



Constraints

- 1. $v_{final} \le 16.7\ m/s$

$$F_d = \frac{C_d A_p \rho v^2}{2}$$

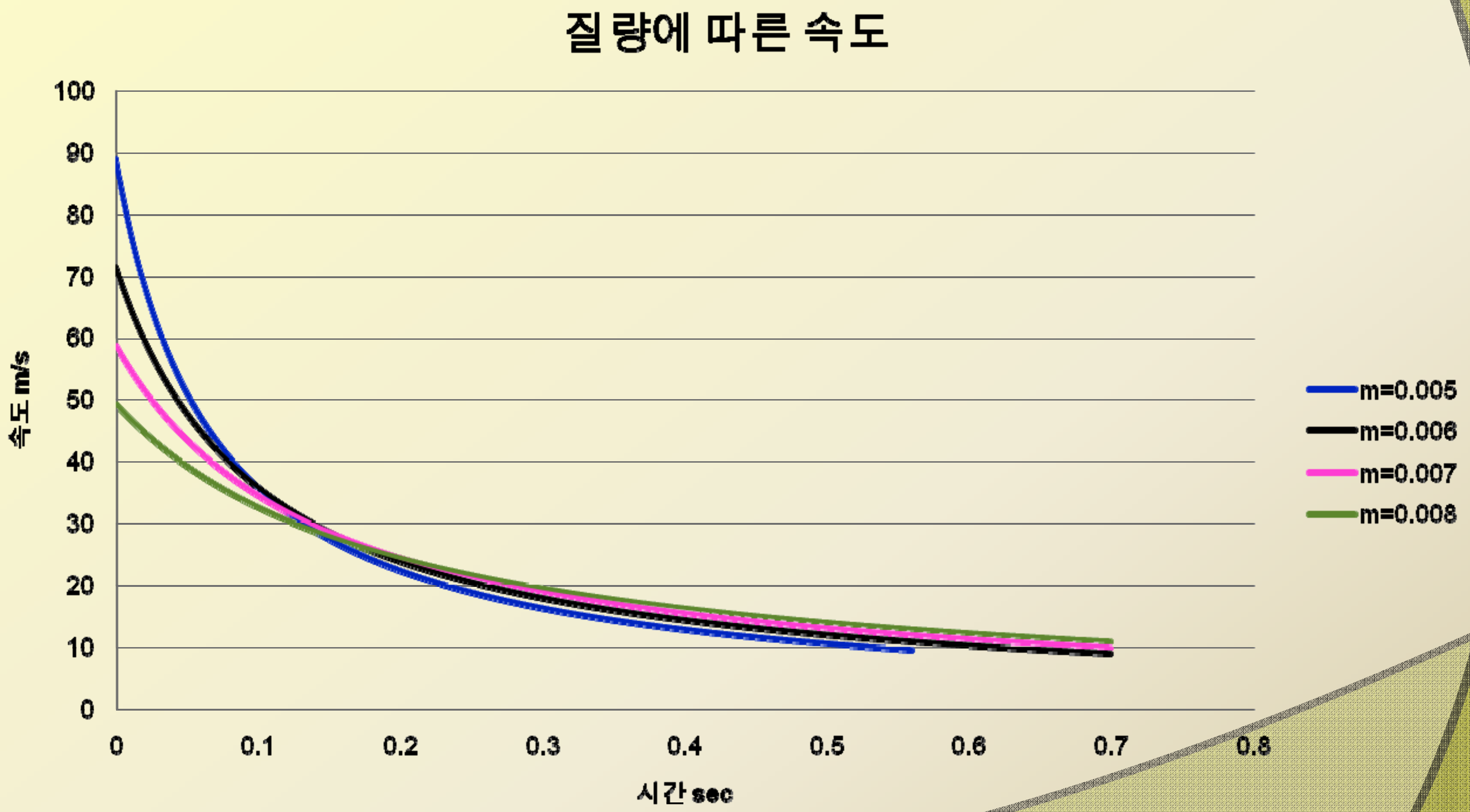
$$C_d = 0.49, A_p = \frac{\pi D_2^{\ 2}}{4}, \rho = 1.2 kg/m^3$$

$$m\frac{dv}{dt} = -F_d$$

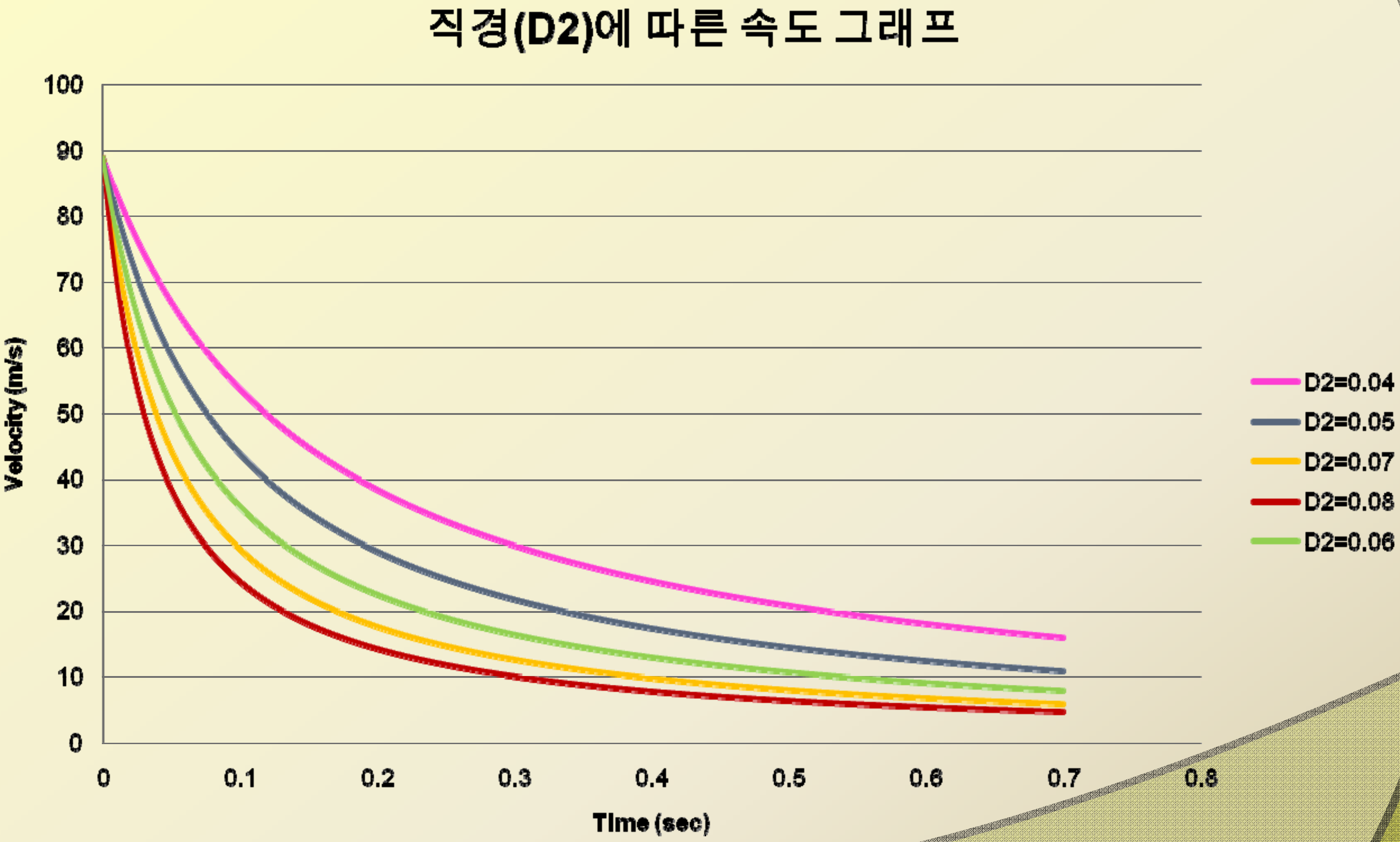
$$m\frac{dv}{dt} = -\frac{C_d A_p \rho v^2}{2} \rightarrow v_{i+1} = v_i - \frac{C_d A_p \rho}{2} v_i^{\ 2} \Delta t$$

(수치해석적으로 풀이)

Constraints

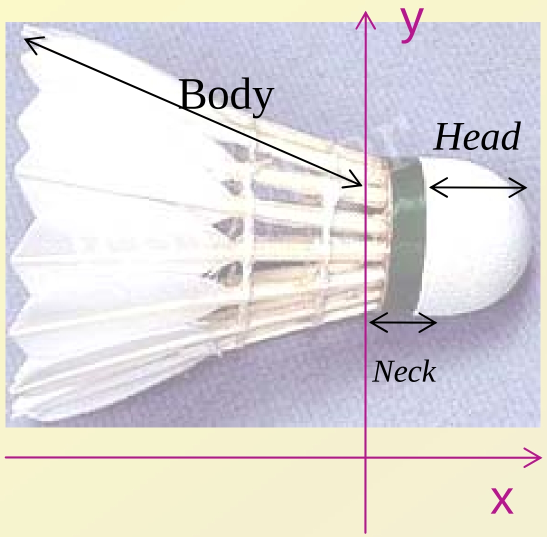


Constraints



Constraints

- 2.Center of gravity ≥ 0



$$l_{neck} = 0.001\, m, \quad l_{body} = 0.07\ m$$

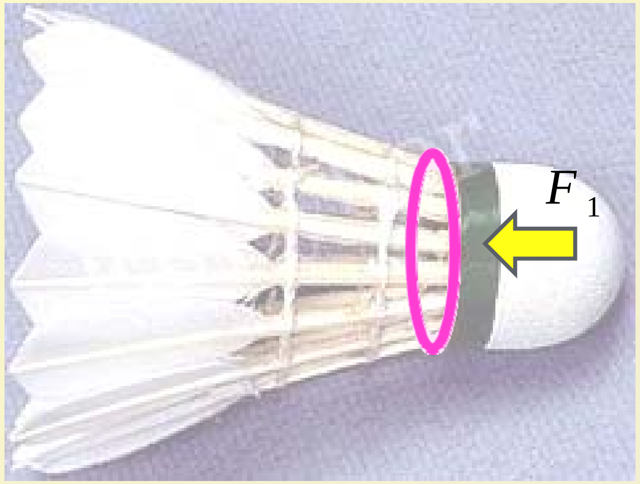
$$\text{center of gravity } \bar{x} = \frac{\int x dW}{W}$$

$$\bar{x}_{total} = \frac{\sum (\bar{x}_{b,out} W_{b,out} - \bar{x}_{b,in} W_{b,in} + \bar{x}_h W_h + \bar{x}_n W_n)}{W_{total}}$$

$$\geq 0$$

Constraints

- 3.Stress $\leq \sigma_{all}$

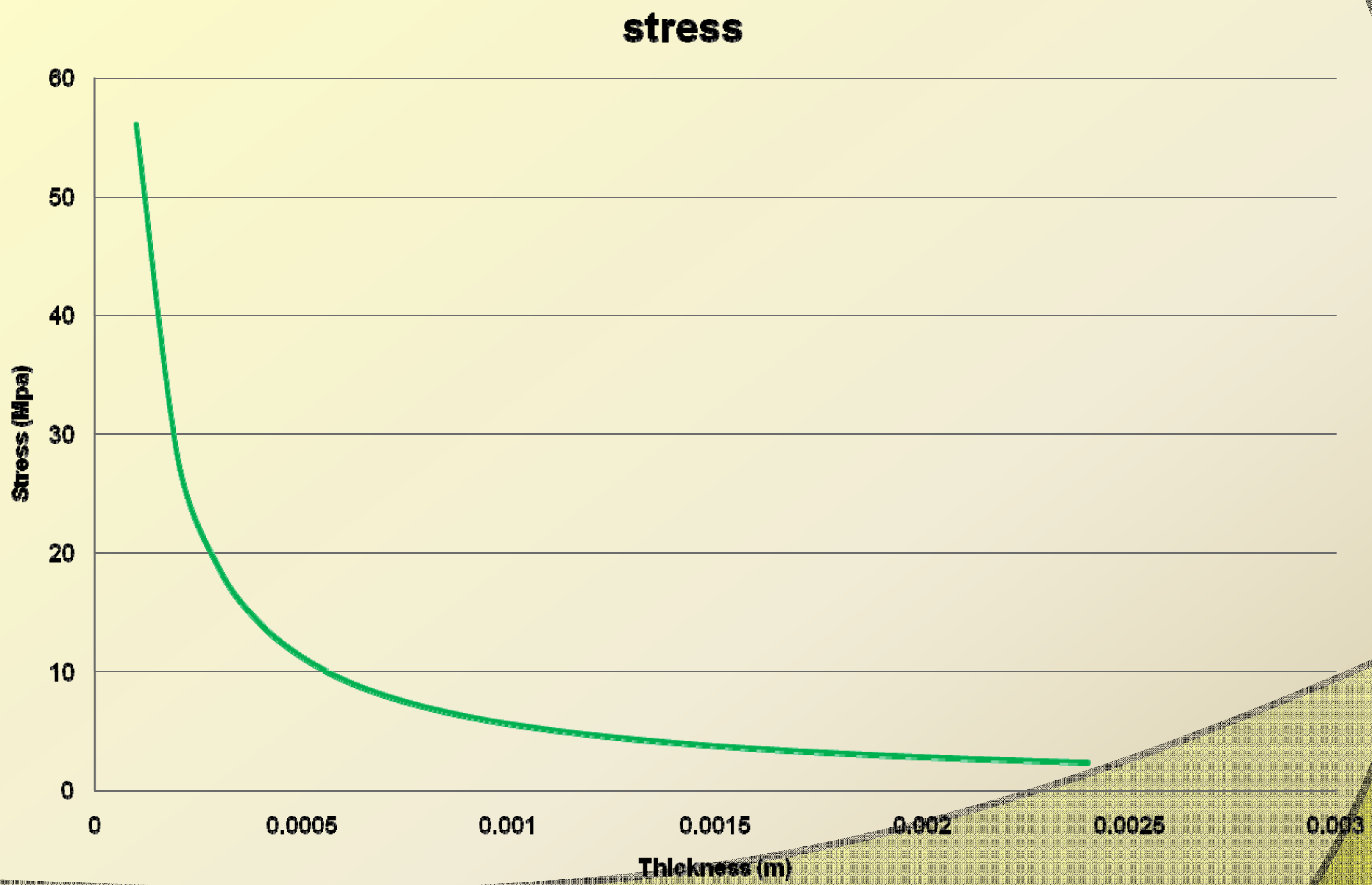


$$F_1 = F \times \frac{m_{body}}{m_{tatal}}$$

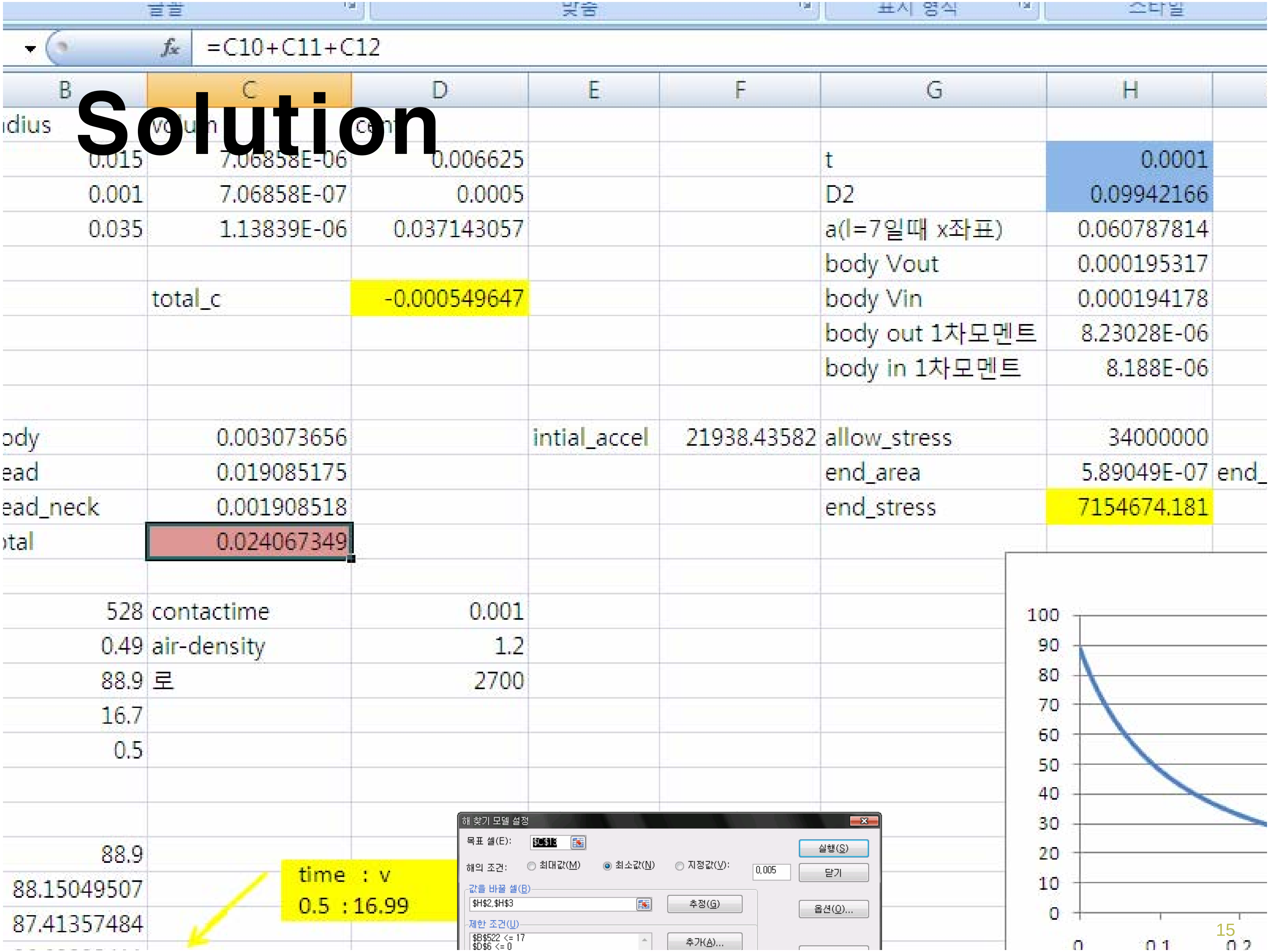
$$= F \times \frac{16(\pi D_1)t}{16(\pi D_1)t + \pi \frac{D_1}{4} l_{neck} + \frac{2}{3}\pi(\frac{D_1}{2})^2}$$

$$\sigma = \frac{F_1}{A} = \frac{F_1}{\pi D_1 t} \leq \sigma_{all}$$

Constraints



Solution



=C10+C11+C12
B
C
D
E
F
G
H
adius
0.015
7.06858E-06
0.006625
0.001
7.06858E-07
0.0005
0.035
1.13839E-06
0.037143057
total_c
-0.000549647
t
0.0001
D2
0.09942166
a(l=7일때 x좌표)
0.060787814
body Vout
0.000195317
body Vin
0.000194178
body out 1차모멘트
8.23028E-06
body in 1차모멘트
8.188E-06
ody
0.003073656
intial_accel
21938.43582
allow_stress
34000000
ead
0.019085175
end_area
5.89049E-07
end_
ead_neck
0.001908518
end_stress
7154674.181
tal
0.024067349
528
contactime
0.001
0.49
air-density
1.2
88.9
로
2700
16.7
0.5
88.9
88.15049507
87.41357484
time : v
0.5 : 16.99
해 찾기 모델 설정
목표 셀(E):
해의 조건:
최대값(M)
최소값(N)
지정값(V):
0.005
실행(S)
닫기
값을 바꿀 셀(B)
H2,H3
추정(G)
옵션(O)...
제한 조건(U)
B522 <= 17
D6 <= 0
추가(A)...
100
90
80
70
60
50
40
30
20
10
0
0
0.1
0.2

Future works

- 금속 박판이므로 집중응력을 받을 시에 예상되는 집중응력의 정확한 해석
- 무게 경량화를 위한 새로운 설계변수 설정
- 형태보정에 따른 유체저항의 정확성 해석

References

- 대한 배드민턴 협회
  koreabadminton.org
- 변형 및 파괴역학
  이동녕,김정수,이성근 공역
- Mechanical engineer's handbook
  Myer Kutz
- http://www.scribd.com/doc/3999295/Fisika-Curved-Motion-of-A-Shuttlecock-by-Dhina-Pramita-Susanti