

Multilink Suspension 분석

오른쪽	뒷바퀴
2014012615	유영준
2014012415	김민욱
2014012551	소지용

index

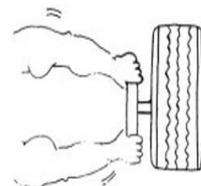
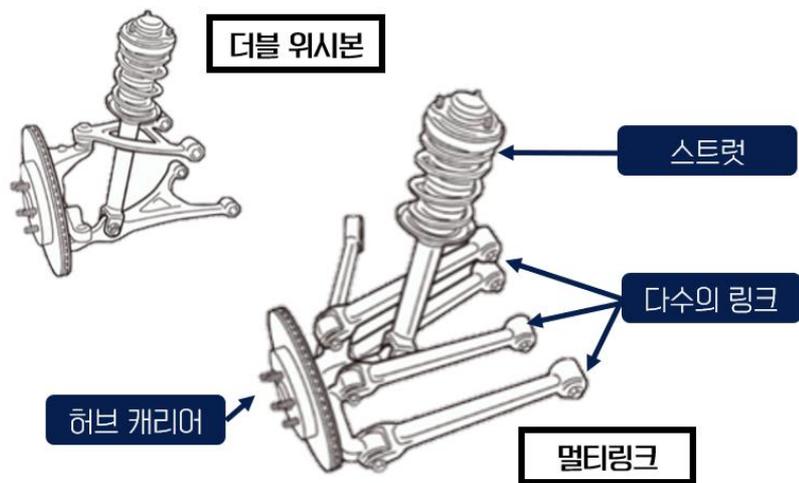
1. Multilink suspension
2. 선회조건에서 서스펜션으로 힘 전달
3. Comsol을 이용한 분석
4. 고찰

Multilink Suspension

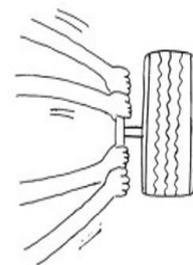


“오른쪽 뒷바퀴”

Multilink Suspension



더블 위시본



멀티링크

선회조건에서 서스펜션으로 힘 전달

1

선회시 바퀴별 횡력 및 하중계산

2

수학적 모델링

3

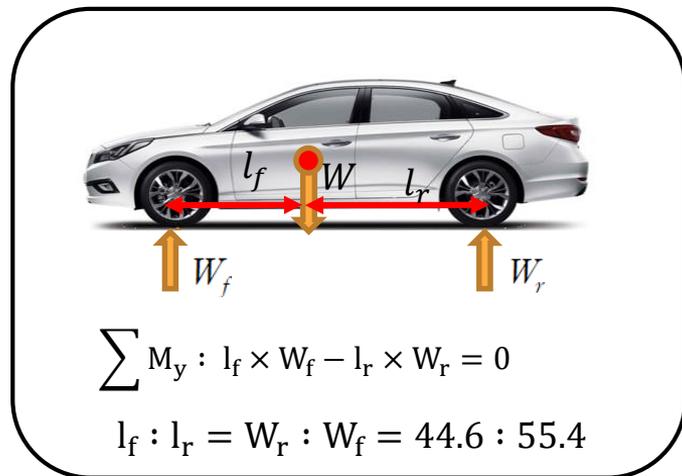
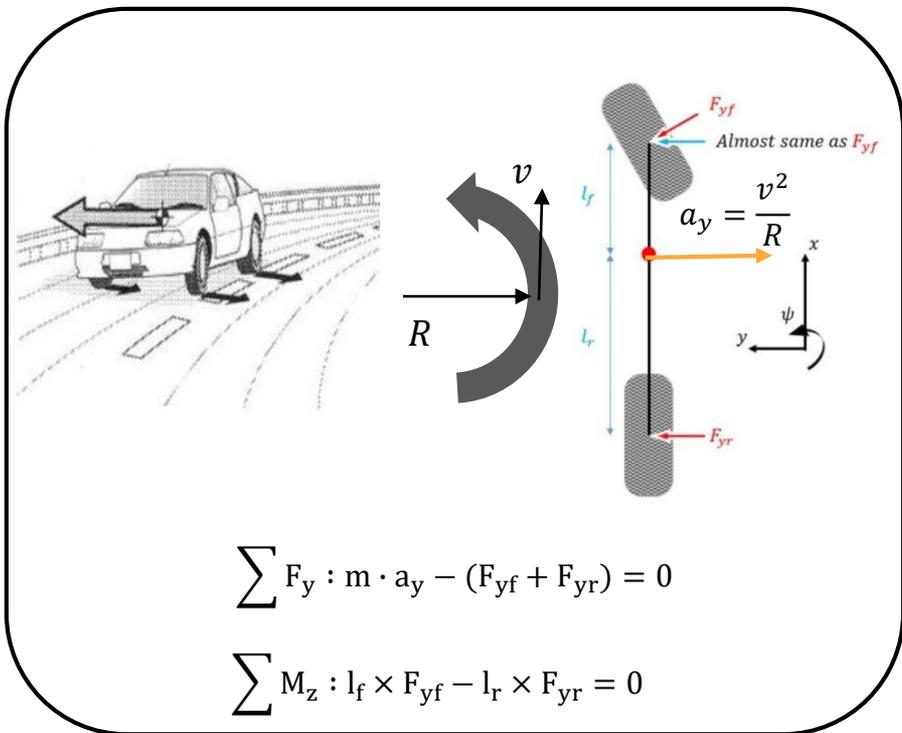
Arm 분력 계산

바퀴별 횡력 및 하중계산 - 횡력

1

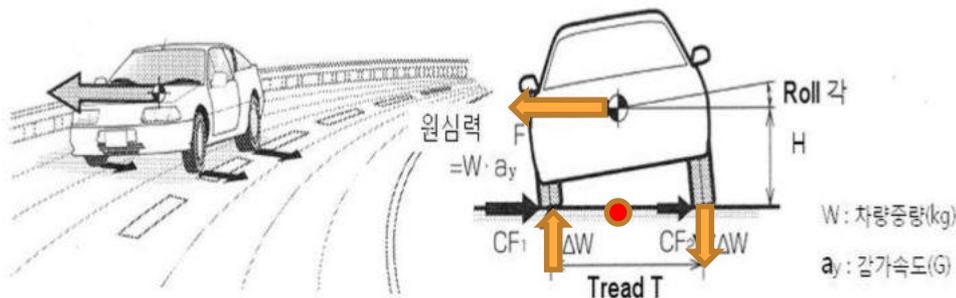
2

3



$\therefore F_{yf} = \frac{l_r}{l_f + l_r} \times m \cdot a_y = 0.554 \times m \times a_y$
 $F_{yr} = \frac{l_f}{l_f + l_r} \times m \cdot a_y = 0.446 \times m \times a_y$

바퀴별 횡력 및 하중계산 - 하중



ΔW : 외륜 ← 내륜 하중이동

$$\sum M_x : m \cdot a_y \times H - (\Delta W \times \frac{T}{2} + \Delta W \times \frac{T}{2}) = 0$$

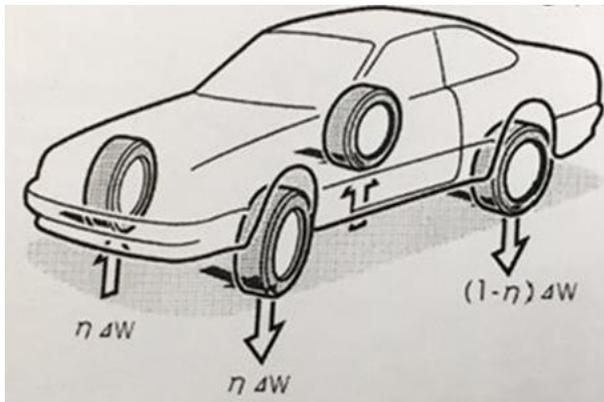
$$\therefore \Delta W = \frac{m \cdot a_y \times H}{T}$$

1

2

3

바퀴별 횡력 및 하중계산 - 하중



$$\sum W_{f(\text{in})} = 0.554 \times \frac{W}{2} - 0.554 \times \Delta W$$

$$\sum W_{r(\text{in})} = 0.446 \times \frac{W}{2} - 0.446 \times \Delta W$$

$$\sum W_{f(\text{out})} = 0.554 \times \frac{W}{2} + 0.554 \times \Delta W$$

$$\sum W_{r(\text{out})} = 0.446 \times \frac{W}{2} + 0.446 \times \Delta W$$

‘하중 = 정지상태 하중 + 하중이동’

바퀴별 횡력 및 하중계산 - 계산 결과

1

2

3

주행조건	
속도(km/h)	100
선회반경(m)	80
횡가속도(m/ss)	9.645062
차량제원 (소나타)	
휠베이스(m)	2.8
트레드(m)	1.6
타이어 반경(m)	0.225
중량(kg)	1600
무게중심(m)	0.5
후륜중량배분(%)	44.6

횡력(N)	
전륜	4274.691
후륜	3441.358

하중(N)	
W.f.(in)	1676.11
W.f.(out)	7019.474
W.r.(in)	1349.359
W.r.(out)	5651.057

수학적 모델링 Assumption

1



1. Assist arm & Upper arm

- 주로 횡력에 의한 인장, 압축력을 견딤

➡ truss

2



2. Trailing arm

- 주로 진행방향 힘과 모멘트를 견딤

➡ Beam

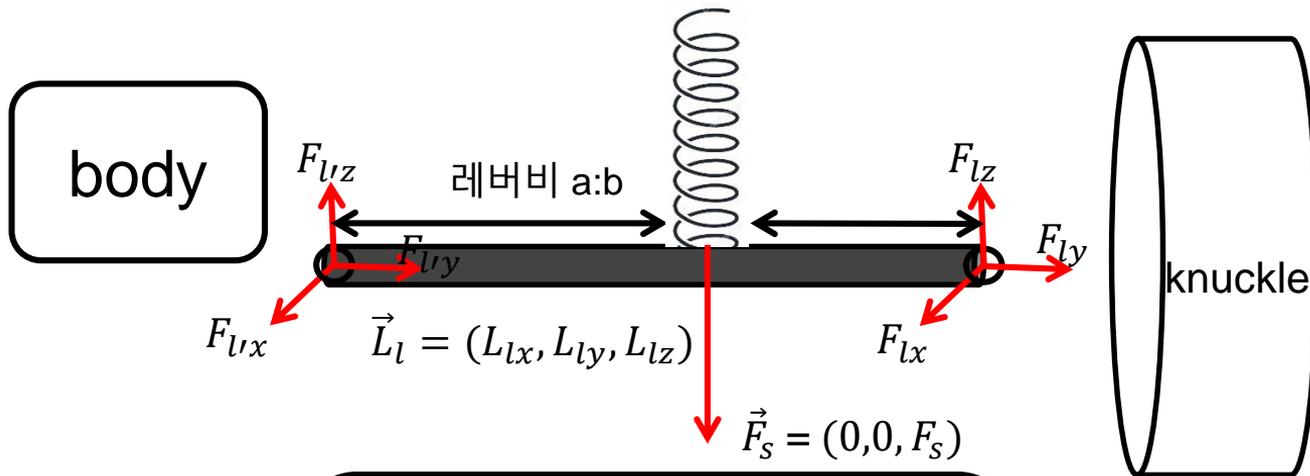
3

3. Lower arm

- shock absorber를 지지하며
수직력, 횡력, 모멘트를 모두 견딤

➡ Beam

Arm 분력 계산 – Lower arm



- 힘 평형

$$\sum \vec{F}_{lower} : \vec{F}_l + \vec{F}_l + \vec{F}_s = \vec{0}$$

- 모멘트 평형

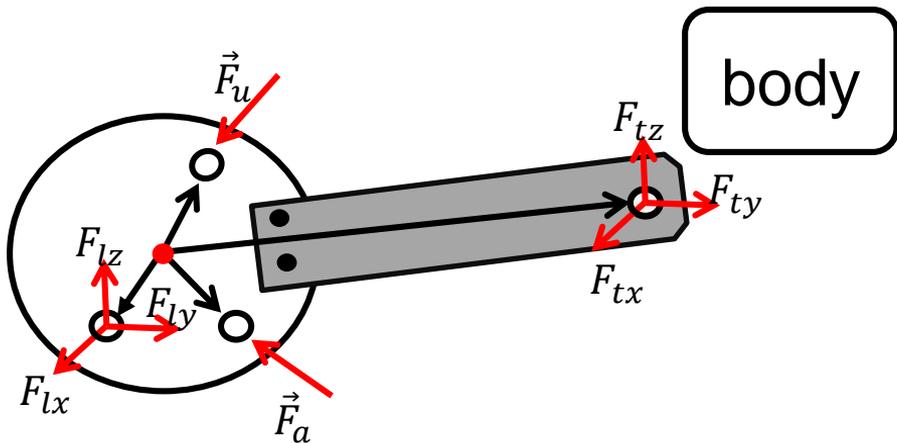
$$\sum \vec{M}_{lower} : \vec{L}_s \times \vec{F}_s + \vec{L}_l \times \vec{F}_l = \vec{0}$$

1

2

3

Arm 분력 계산 – knuckle



- 힘 평형

$$\sum \vec{F}_{knuckle} : \vec{F}_a + \vec{F}_u + \vec{F}_t + \vec{F}_l = \vec{0}$$

- 모멘트 평형

$$\sum \vec{M}_{knuckle} : \vec{r}_a \times \vec{F}_a + \vec{r}_u \times \vec{F}_u + \vec{r}_t \times \vec{F}_t + \vec{r}_l \times \vec{F}_l = \vec{0}$$

Arm 분력 계산

< 방정식 및 변수 종합 >

$$\sum M_{lx} : \left(\frac{a}{a+b}L_{ly}F_s\right) + (L_{ly}F_{lz} - L_{lz}F_{ly}) = 0$$

$$\sum M_{ly} : \left(-\frac{a}{a+b}L_{lx}F_s\right) + (L_{lz}F_{lx} - b_{lx}F_{lz}) = 0$$

$$\sum F_x : F_a e_{ax} + F_u e_{ux} + F_{lx} + F_{tx} = 0$$

$$\sum F_y : F_a e_{ay} + F_u e_{uy} + F_{ly} + F_{ty} - CF = 0$$

$$\sum F_z : F_a e_{az} + F_u e_{uz} + F_{lz} + F_{tz} + W = 0$$

$$\sum \vec{M}_x : r_{ay}e_{az}F_a - r_{az}e_{ay}F_a + r_{uy}e_{uz}F_u - r_{uz}e_{uy}F_u + r_{ty}F_{tz} - r_{tz}F_{ty} + r_{ly}F_{lz} - r_{lz}F_{ly} - CF \times R = 0$$

$$\sum \vec{M}_y : r_{az}e_{ax}F_a - r_{ax}e_{az}F_a + r_{uz}e_{ux}F_u - r_{ux}e_{uz}F_u + r_{tz}F_{tx} - r_{tx}F_{tz} + r_{lz}F_{lx} - r_{lx}F_{lz} = 0$$

$$\sum \vec{M}_z : r_{ax}e_{ay}F_a - r_{ay}e_{ax}F_a + r_{ux}e_{uy}F_u - r_{uy}e_{ux}F_u + r_{tx}F_{ty} - r_{ty}F_{tx} + r_{lx}F_{ly} - r_{ly}F_{lx} = 0$$

1

2

3

Arm 분력 계산 - 행렬

$$Ku = f \longrightarrow u = K^{-1}f$$

K

방정식/변수			F.s	F.a	F.u	F.lx	F.ly	F.lz	F.tx	F.ty	F.tz
과구속			0	0	0	0	0	0	0	1	0
로우암	모멘트	Y	0.59568	0	0	0	-0.118	0.9928	0	0	0
		Z	0	0	0	-0.9928	0.0228	0	0	0	0
너클	힘	X	0	-0.0935	-0.0265	-1	0	0	1	0	0
		Y	0	-0.9779	-0.9994	0	-1	0	0	1	0
		Z	0	-0.187	-0.0223	0	0	-1	0	0	1
	모멘트	X	0	-0.11468	0.13364	0	-0.132	0.077	0	-0.052	-0.201
		Y	0	-0.00655	-0.0035	0.132	0	0.101	0.052	0	0.521
		Z	0	0.09157	-0.00204	-0.077	-0.101	0	0.201	-0.521	0

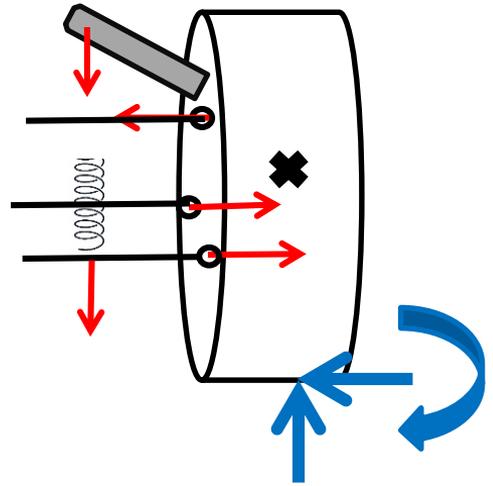
Arm 분력 계산 - 계산 결과

f

input (힘력 및 하중)	
	0
	0
	0
	0
힘력	3441.36
하중	-5651.06
모멘트	774.306
	0
	0

u

output (분력)	
F.s	-8508.4
F.a	-1202.34
F.u	-884.656
F.lx	-31.6819
F.ly	-1381.47
F.lz	4941.4
F.tx	-167.544
F.ty	0
F.tz	-954.225



1

2

3

Comsol을 이용한 분석

1

Assist(upper) arm

2

Trailing arm

3

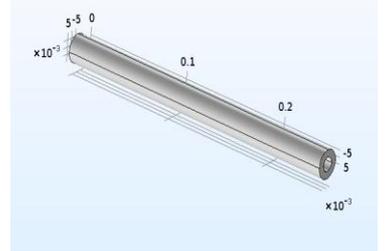
Lower arm

Comsol을 이용한 분석 - assist arm

- 기하구조

1

1. 선회조건에서 작은 Axial force만 작용



2

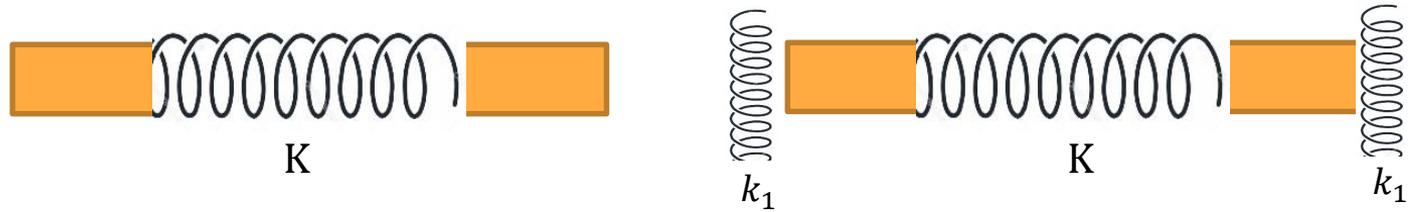
2. 양끝에 부싱이 달려있음
-> Comsol에서 spring으로 modeling



3

Comsol을 이용한 분석 – assist arm

1



Steel일때,
$$K = \frac{EA}{L} = 1.93 \times 10^8 [\text{N/m}]$$

Assist arm이 변형



부싱이 대신 변형

2

3

Comsol을 이용한 분석 – assist arm

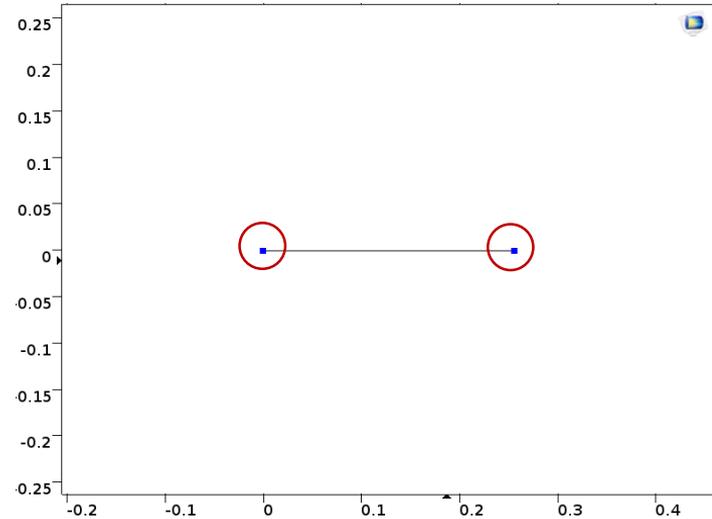
- 부싱이 있는 경우

1

2

3

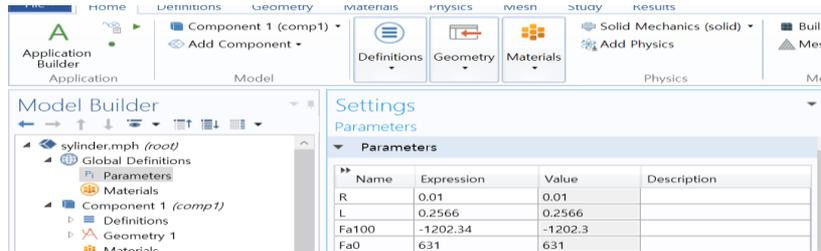
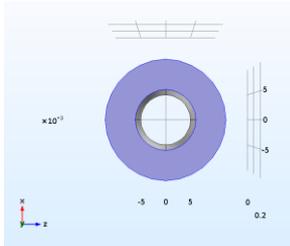
▼ Force	
F_p	User defined
-Fa100	x
0	y
N	
▼ Force	
F_p	User defined
Fa100	x
0	y
N	
Spring type:	
Spring constant	
k_p	0
0	K
N/m	



PART.3

Comsol을 이용한 분석 – assist arm

- 부싱이 없는 경우



1

- materials
- component 1 (comp1)
- Definitions
- Geometry 1
- Materials
- Truss (truss)
 - Linear Elastic Material 1
 - Cross Section Data 1
 - Straight Edge Constraint 1
 - Free 1
 - Initial Values 1
 - Spring Foundation 1
 - Point Load 1
 - Point Load 2
- Mesh 1
- tudy 1
- results
- Data Sets
- Derived Values

Selection: All boundaries

1

Active

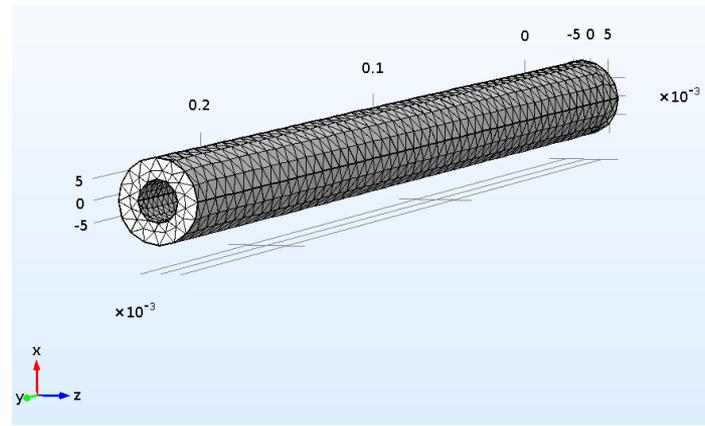
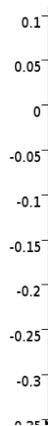
Override and Contribution

Equation

Cross Section Data

Area:

A $\pi^3/4 \cdot R^2$ m²



2

3

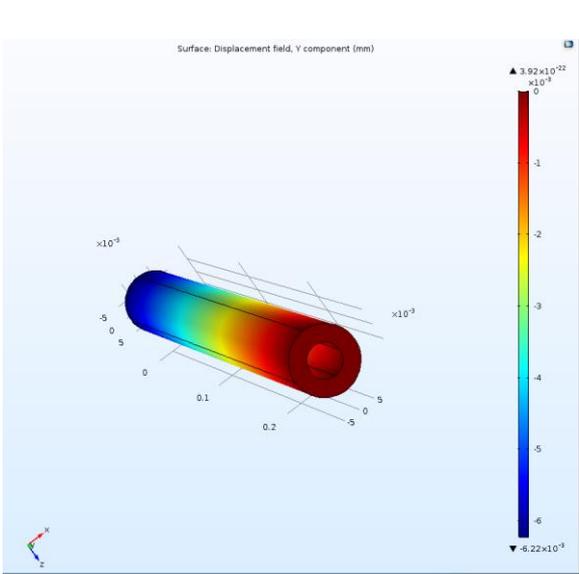
PART.3

Comsol을 이용한 분석 – assist arm

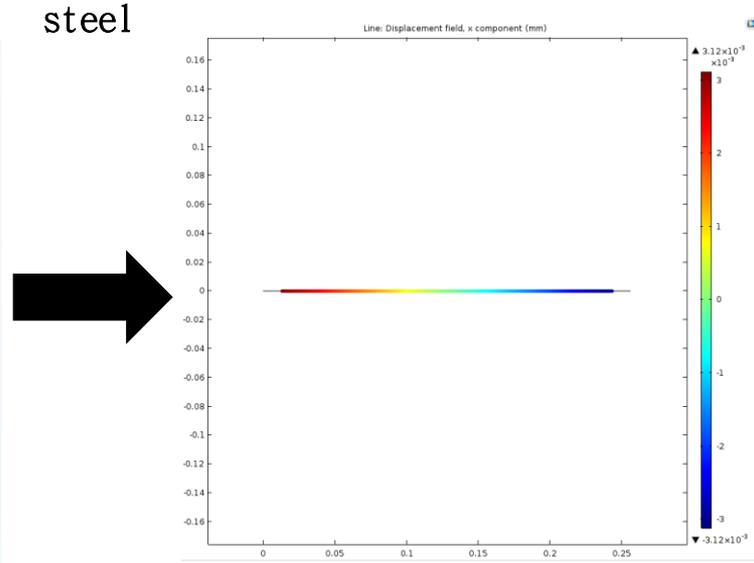
1

2

3



변형량(mm)
6.22E-03
< 부싱 X >



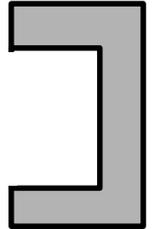
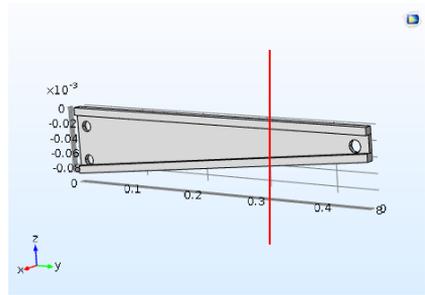
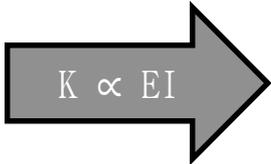
변형량(mm)
3.22E-03
< 부싱 0 >

PART.3

Comsol을 이용한 분석 - trailing arm

- 기하구조

1. Axial force보다 **Bending**이 주로 작용



2. Trailing arm은 비교적 작은 하중 작용



Steel vs Aluminum

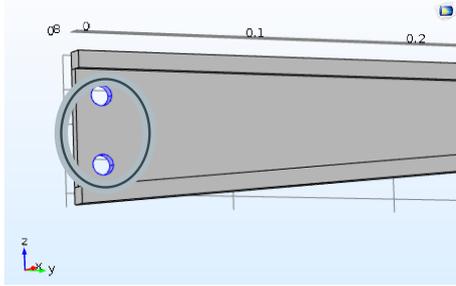
1

2

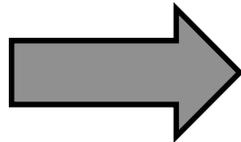
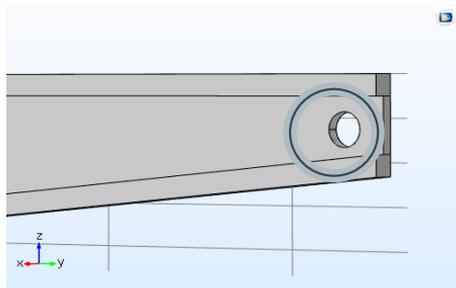
3

Comsol을 이용한 분석 – trailing arm

- Boundary



Fixed Constraint



Load : F.t

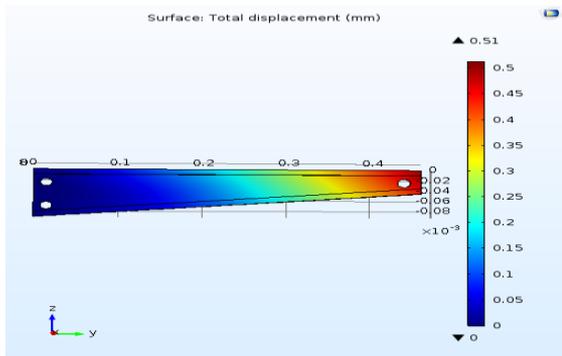
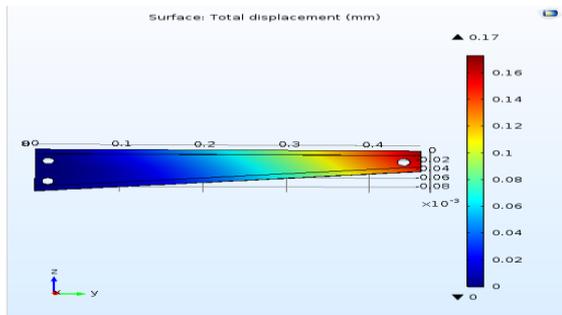
1

2

3

Comsol을 이용한 분석 – trailing arm

- 재질의 변화(E)에 따른 '질량:변형량' 분석



	steel	
	무게(kg)	처짐량(mm)
형상 1	1.5469184	0.2
형상 2	1.6205184	0.17
형상 3	1.79742208	0.16

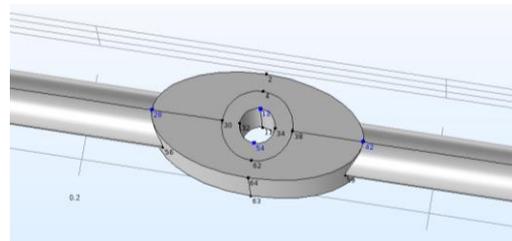
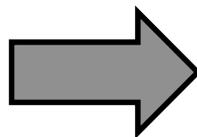
	Al	
	무게(kg)	처짐량(mm)
형상 1	0.52401861	0.58
형상 2	0.54895061	0.51
형상 3	0.60887673	0.46

Comsol을 이용한 분석 - Lower arm

- 기하구조

1. 선회조건에서 가장 큰 하중

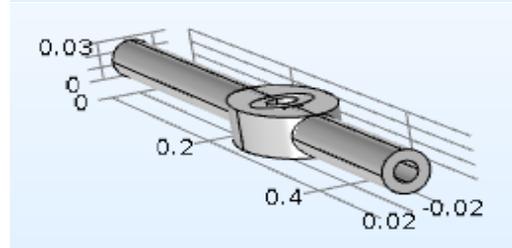
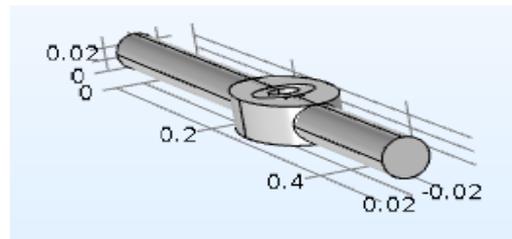
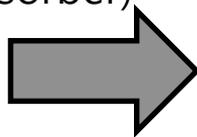
$$\bullet \sigma_{axial} = \frac{F}{A} \propto \frac{1}{A}$$



2. 대부분의 수직력을 견딤 (Shock absorber)

→ **bending**

$$\bullet \sigma_{bending} = \frac{Mc}{I} \propto \frac{1}{I}$$



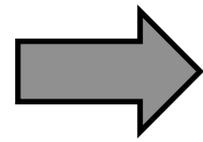
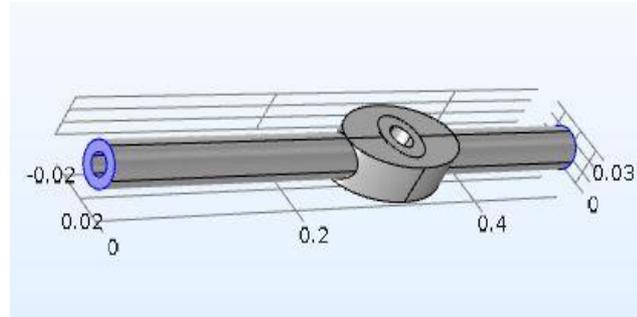
1

2

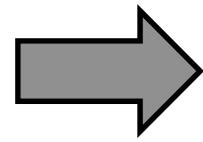
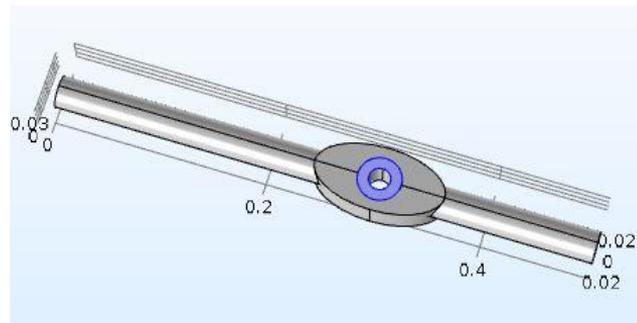
3

Comsol을 이용한 분석 - Lower arm

- Boundary



Fixed Constraint



Load : F.s

1

2

3

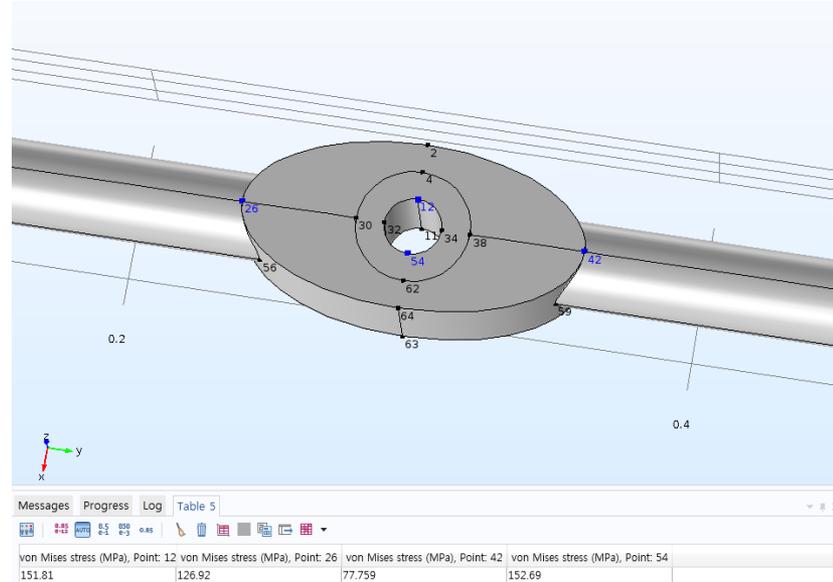
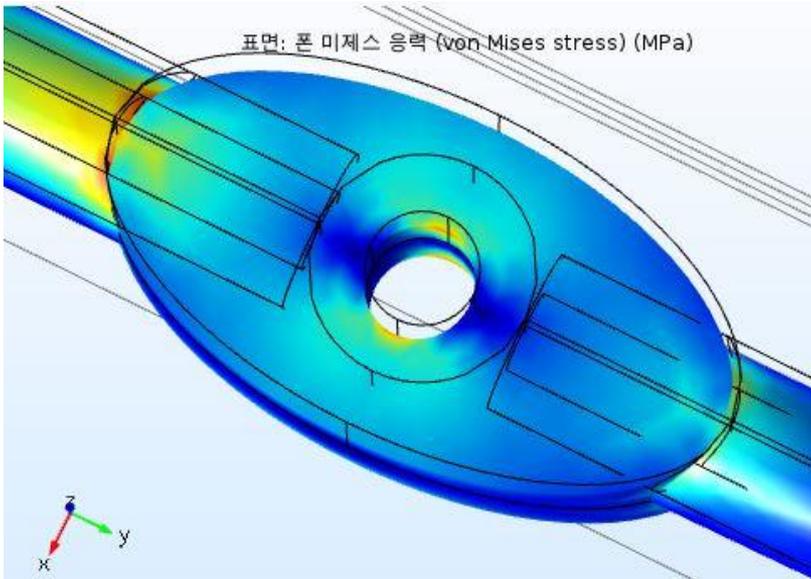
Comsol을 이용한 분석 – Lower arm

- Critical Point

1

2

3



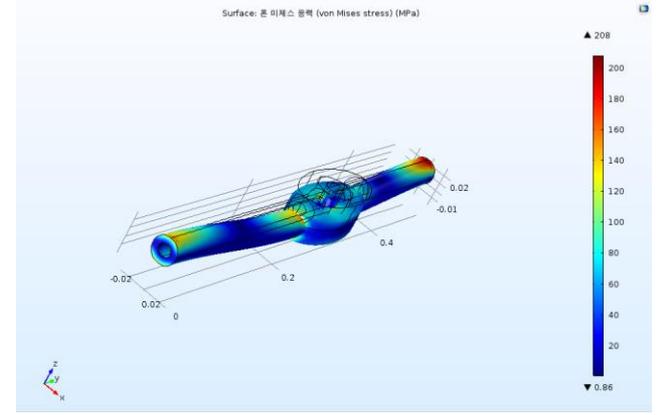
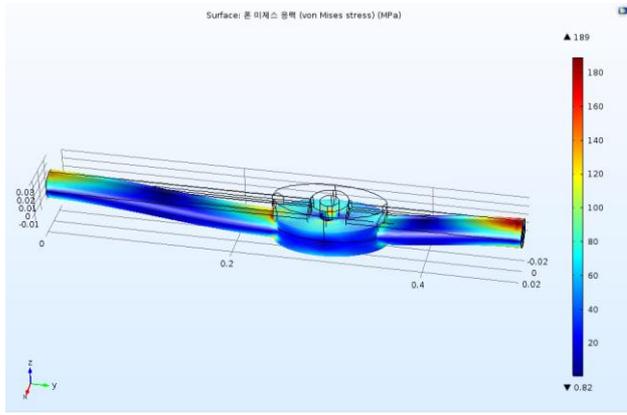
PART.3

Comsol을 이용한 분석 - Lower arm

1

2

3



	원	
	무게(kg)	Stress_critical(Mpa)
형상1	4.14	113
형상2	3.5	152
형상3	2.31	394

	파이프	
	무게(kg)	Stress_critical(Mpa)
형상1	4.13	95.5
형상2	3.51	123.7
형상3	2.31	315.5

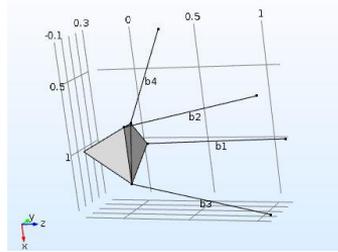
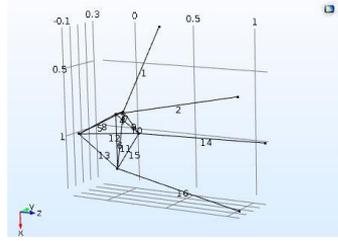
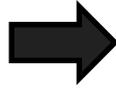
PART.4

고찰

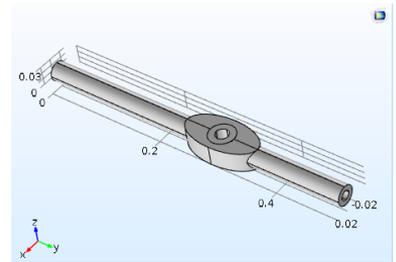
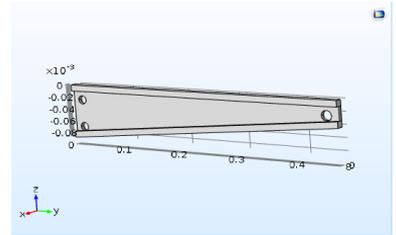
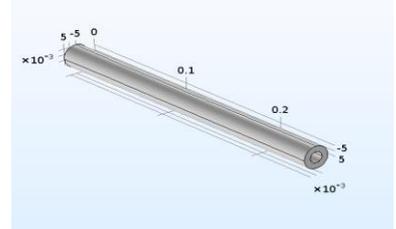
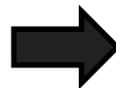
1. Modeling 변화 과정



Multilink



이전에 시도했던 modeling



현재 적용한 modeling

고찰

2. Assist(Upper) arm : 부싱에 의한 강성의 변화를 확인
3. Trailing arm : 재질의 변화(steel vs Al)로 인한 변형량 감소와 무게절감의 trade off 관계 분석
4. Lower arm : 단면 형상의 변화(원->파이프)에 따른 '무게 : 응력' 의 개선 확인
5. 각 arm 별 특징을 고려한 설계 방향성 제시

Q&A

