

#킥보드 #타이어 #공기압

CAEk board

@ 편성현 @ 최범성 @ 이승재

Contents.

- 01 배경
- 02 Boundary Condition
- 03 Comsol – 2D, 3D
- 04 Simulink
- 05 결론



Part 1
Kickboard

배경



Part 1 주제 선정 배경



뜨거운 날씨의 여름에는
타이어 공기압을 높여주세요!

KUMHO TIRE



Part 2

AirPressure

Boundary Condition

Part 2 **Boundary Condition**



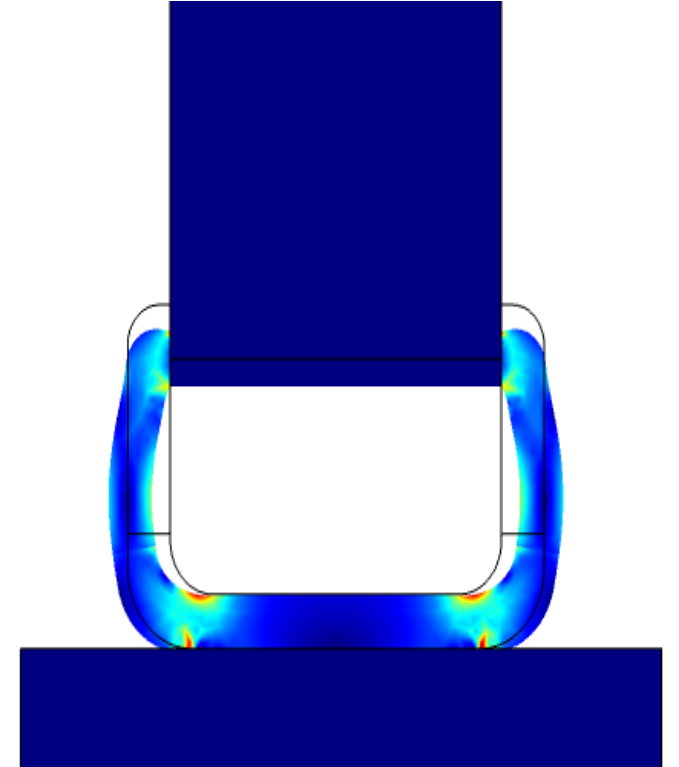
고무의 물성

- Hyperelastic
- Mooney-Rivlin



고정된 요소

- External temperature
- Weight



해석 요소

- Contact area
- Friction heat

Part 2 Boundary Condition

Hyperelastic

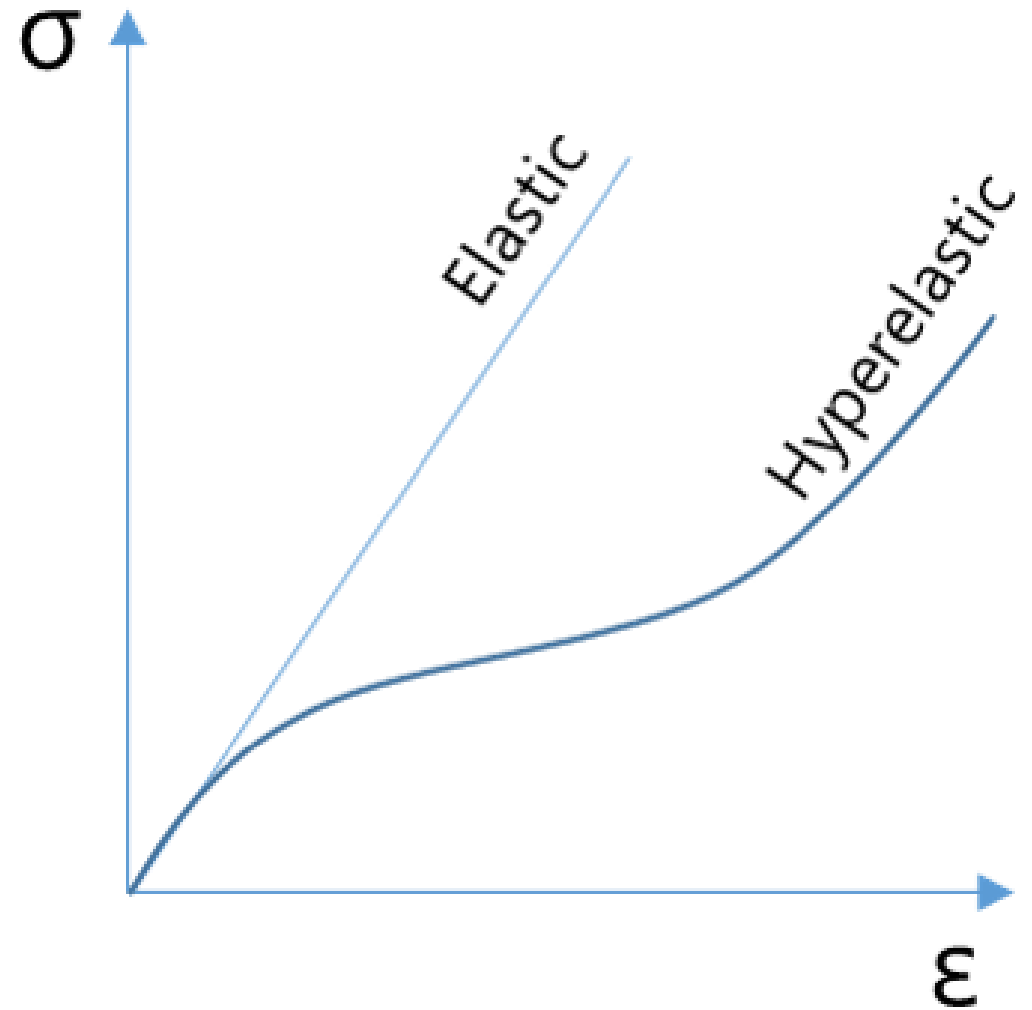
Mooney-Rivlin form

The form of the Mooney-Rivlin strain energy potential is

$$U = C_{10} (\bar{I}_1 - 3) + C_{01} (\bar{I}_2 - 3) + \frac{1}{D_1} (J^{el} - 1)^2$$

$$\bar{I}_1 = \bar{\lambda}_1^2 + \bar{\lambda}_2^2 + \bar{\lambda}_3^2 \quad \text{and} \quad \bar{I}_2 = \bar{\lambda}_1^{(-2)} + \bar{\lambda}_2^{(-2)} + \bar{\lambda}_3^{(-2)}$$

$$\mu_0 = 2(C_{10} + C_{01}), \quad K_0 = \frac{2}{D_1}.$$



Part 2 **Boundary Condition**

Boundary Condition

외부온도

- 여름철 (대기온도 : 40degC 아스팔트 기준 50degC)

하중

- 킥보드 무게 : 14.2kg, 탑승자 무게 : 75kg

속도

- 25km/h (법정 기준 최고 속도)

Product model number	DDHBC02NEB
Max. speed	Approx. 25km/h (Max speed for each mode: ECO: 15km/h; D: 20km/h; S: 25km/h)
General range	45km
Max. climbing angle	12°
Braking	Electrical braking and physical braking
Rated power	300W
Max. power	600W
Tires	8.5 inch front and rear tires
Overvoltage control protection	29V ±0.5V
Controlled current protection	25A ±0.5A
Electric classification	Brushless low-speed current Hall electric motor
Max. load	100kg
Rider height	120-200cm
Rider age	16-50
Working temperature	-10 to 40°C
Storage temperature	-20 to 45°C
Ip Rating	IP54
Charging time	8-9 hours

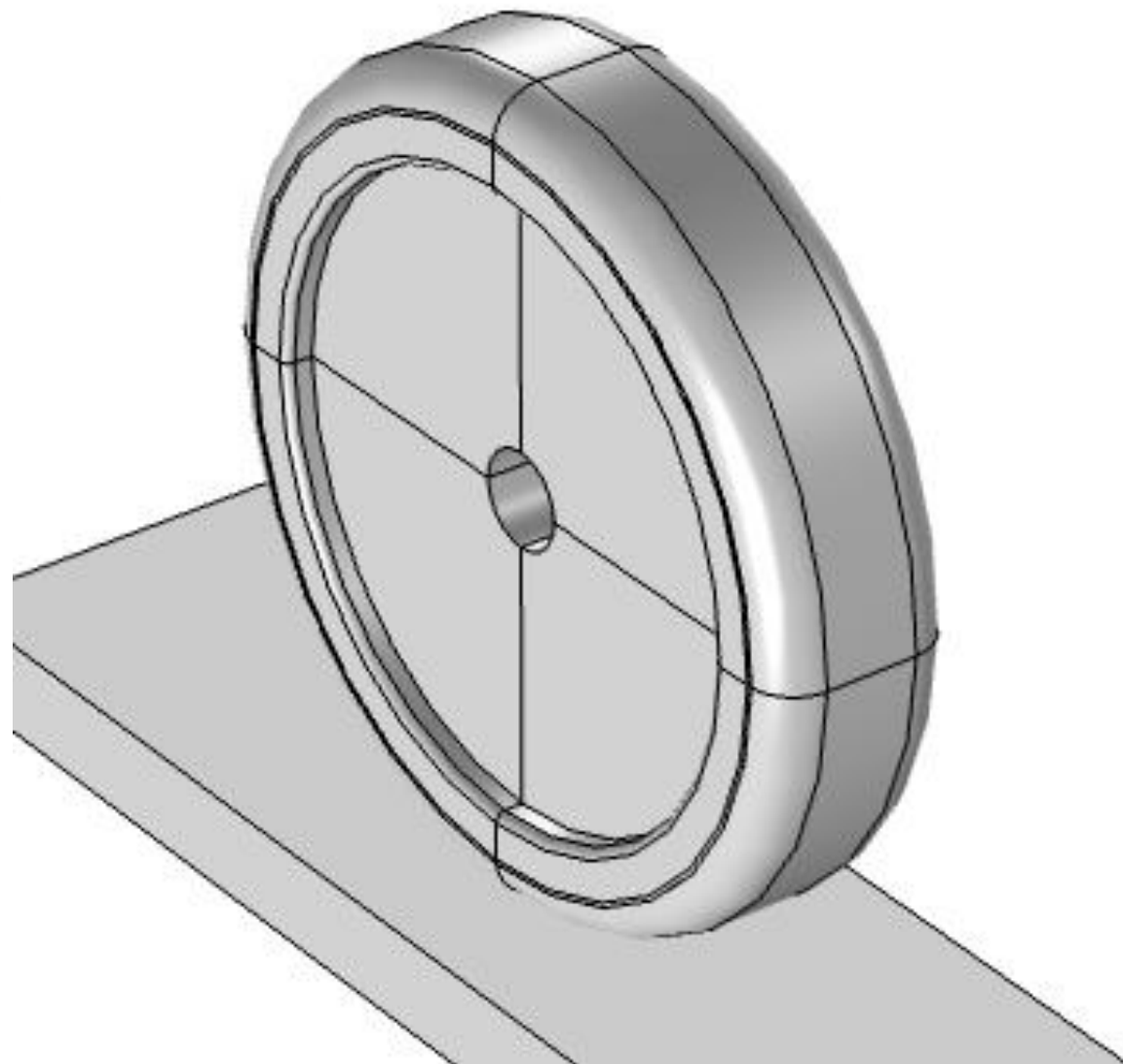
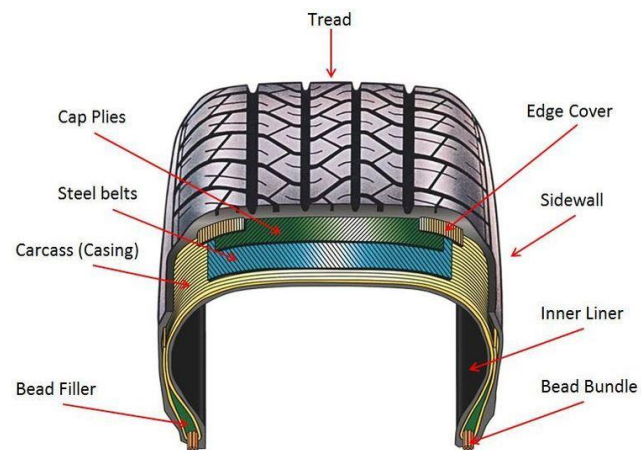
Part 3

2D, 3D Model

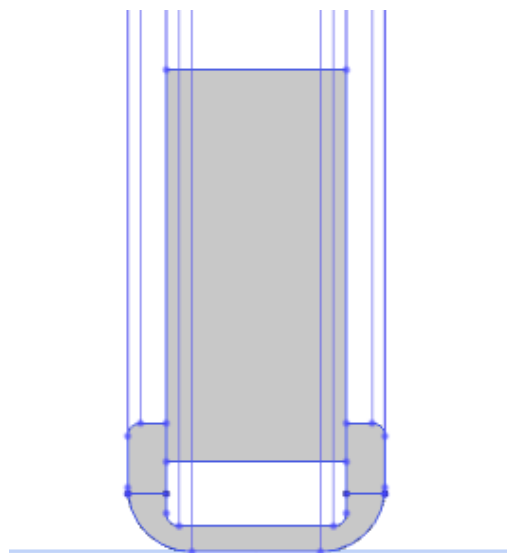
Comsol



Part 3 Comsol - modeling



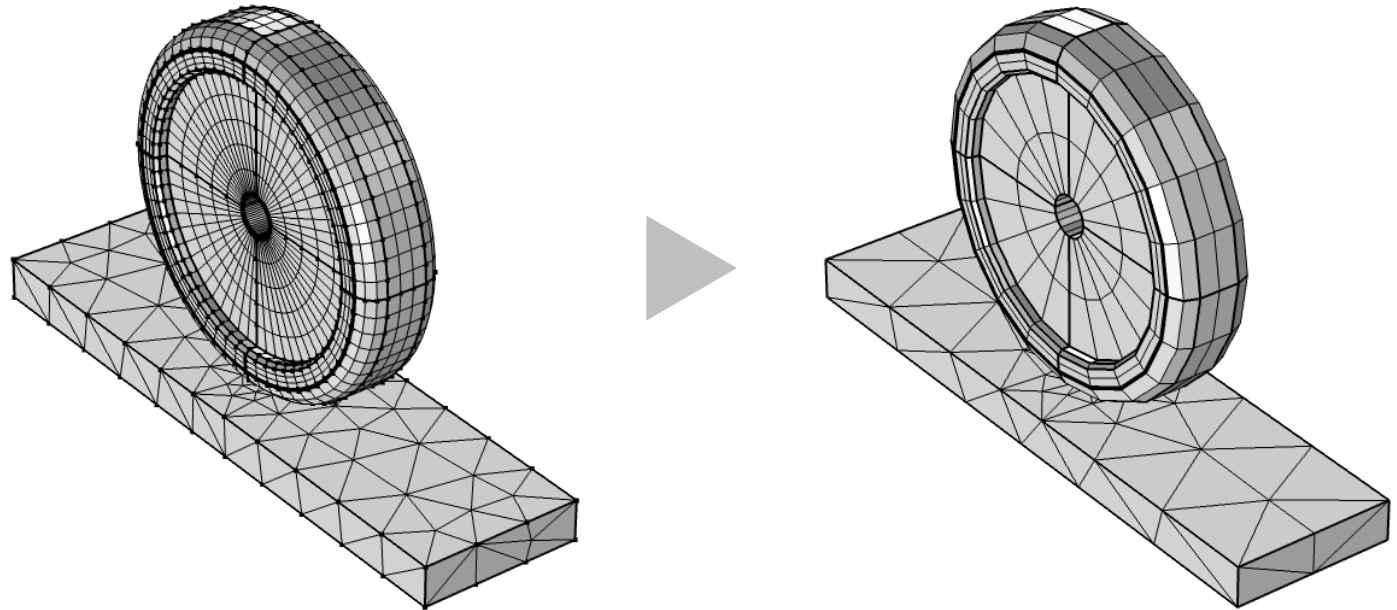
- ▲ Geometry 1
 - Block 1 (*blk1*)
 - ▲ Work Plane 1 (*wp1*)
 - ▲ Plane Geometry
 - Rectangle 2 (*r2*)
 - Rectangle 5 (*r5*)
 - Rectangle 6 (*r6*)
 - Difference 1 (*dif1*)
 - air (*r7*)
 - Fillet 1 (*fil1*)
 - Fillet 2 (*fil2*)
 - Bézier Polygon 1 (*b1*)
 - Bézier Polygon 2 (*b2*)
- ▶ View 2
 - Revolve 2 (*rev2*)
 - Form Union (*fin*)



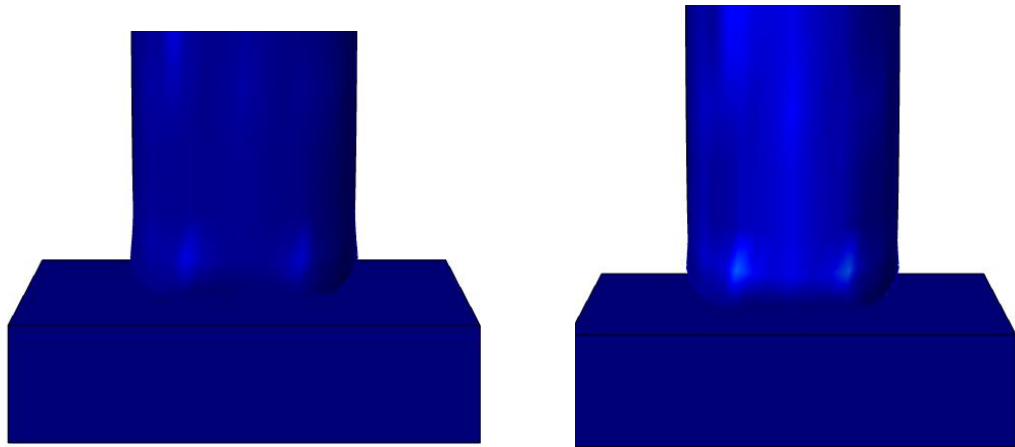
Part 3 Comsol – BC, mesh

- Solid Mechanics (*solid*)
 - Linear Elastic Material 1
 - Free 1
 - Initial Values 1
 - road fixed
 - Contact 1
 - Hyperelastic Material
 - Attachment (wheel - tire)
 - Prescribed y direction
 - air pressure
 - atmosphere
 - weight

- Mesh 1
 - Size
 - Mapped 1
 - Distribution 1
 - Distribution 2
 - Distribution 3
 - Distribution 4
 - Swept 1
 - Free Tetrahedral 1

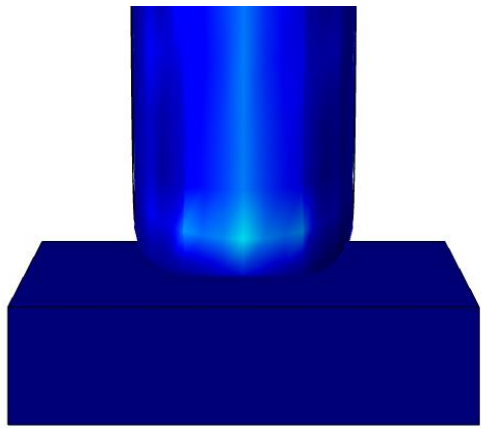


Part 3 Comsol – Study

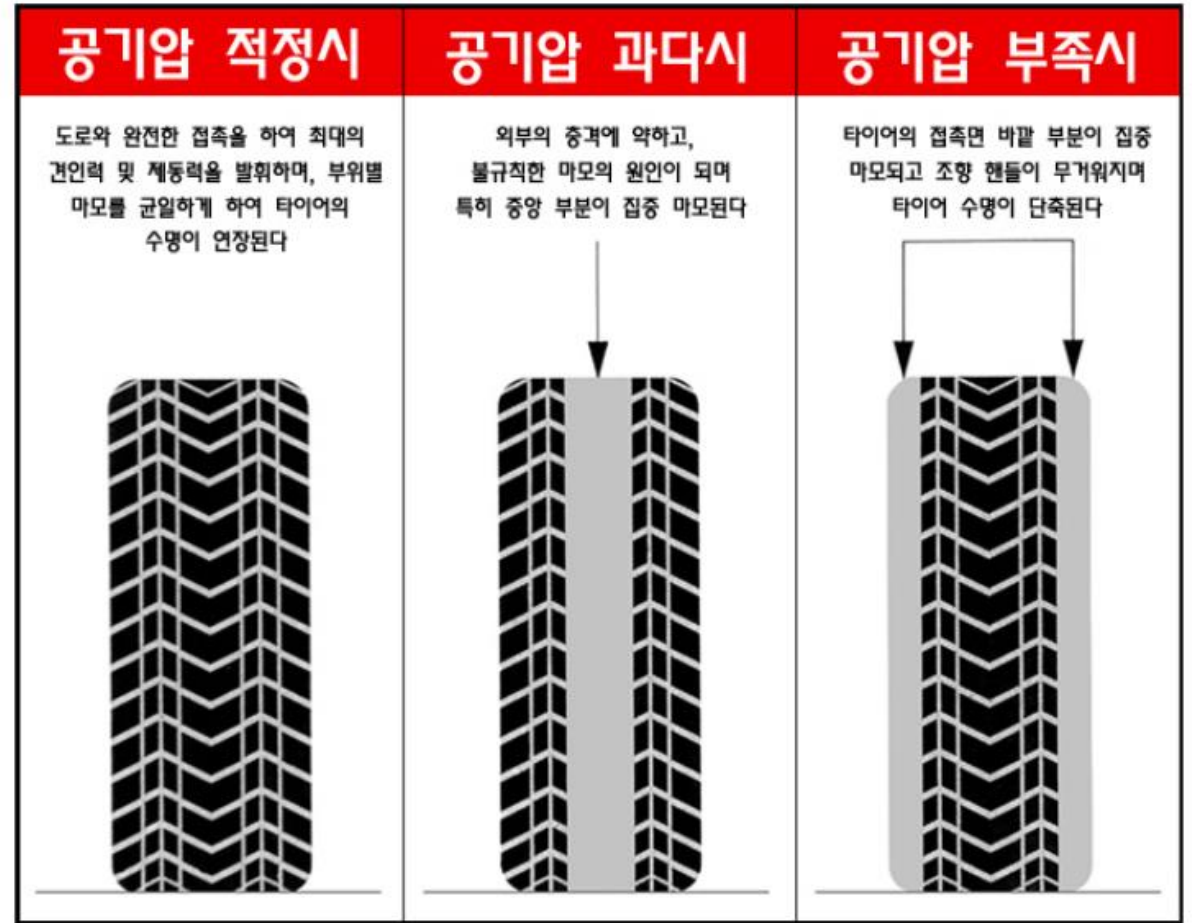


20psi

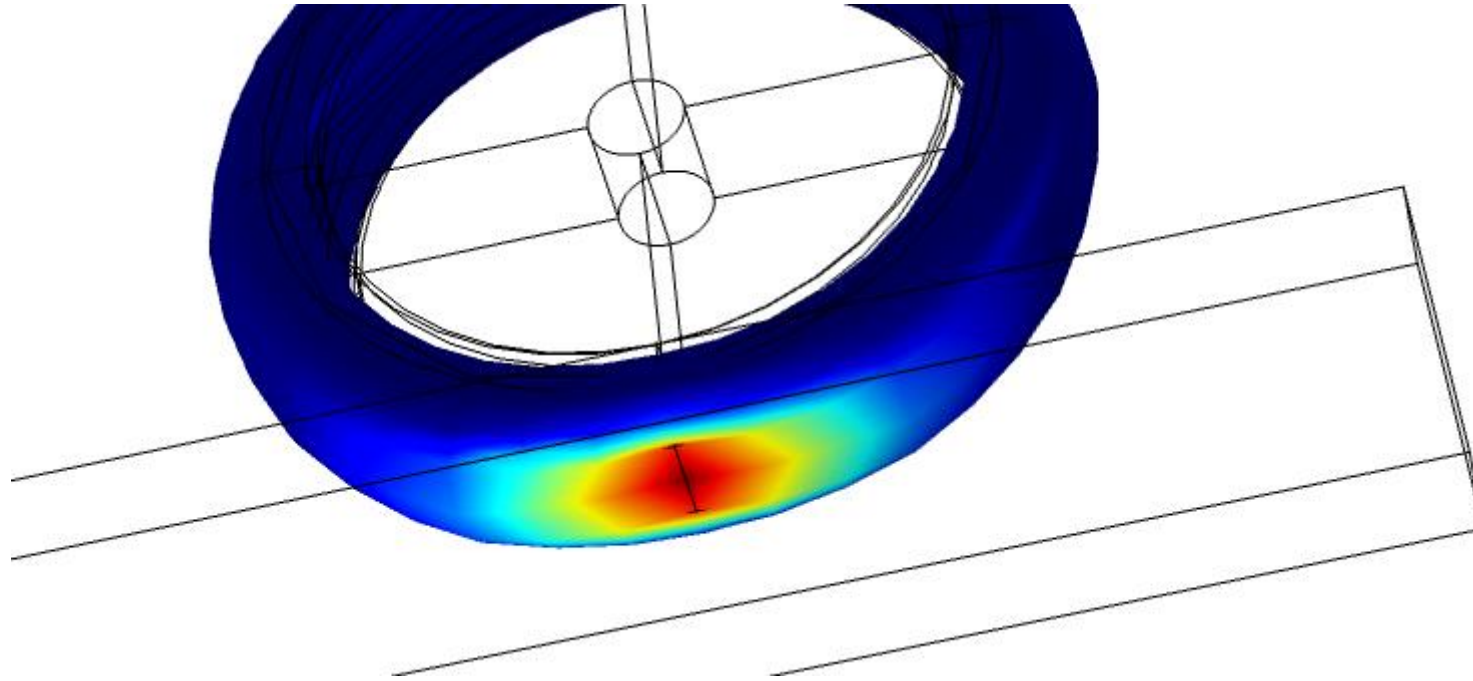
30psi



40psi

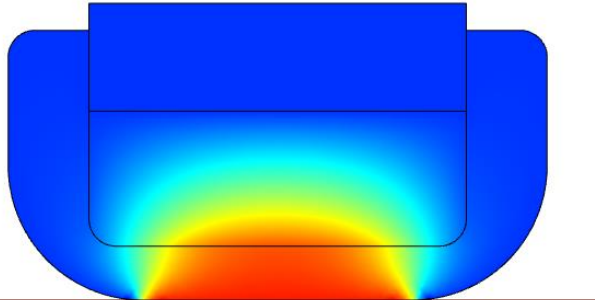
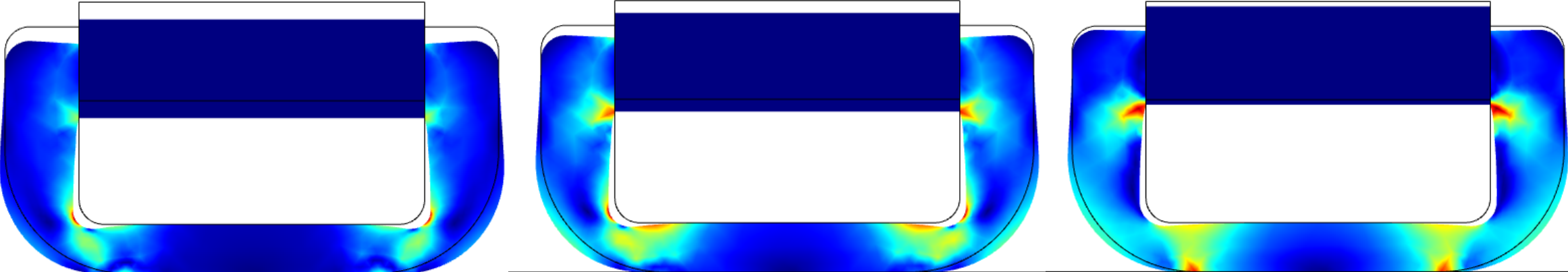


Part 3 Comsol – Study



Pressure(psi)	Contact force(N)	Contact pressure(N/m ²)	Contact area(m ²)	Contact area(inch ²)
20	294.9965969	121764.5047	0.002422681	3.75516339
30	294.9965969	190863.3606	0.00154559	2.395669912
40	294.9965969	275815.7784	0.001069542	1.65779352

Part 3 **Comsol – Study**



Temperature (K)

316.10

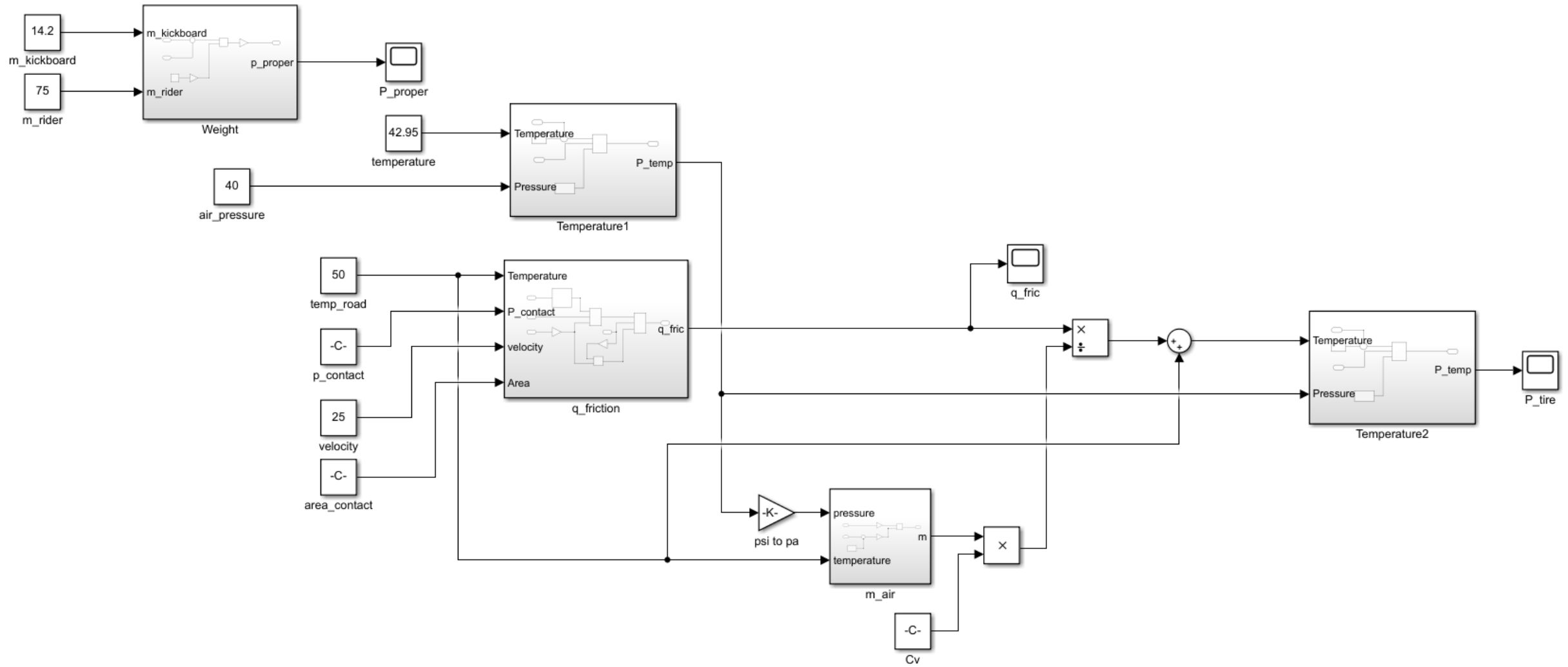
42.95degC



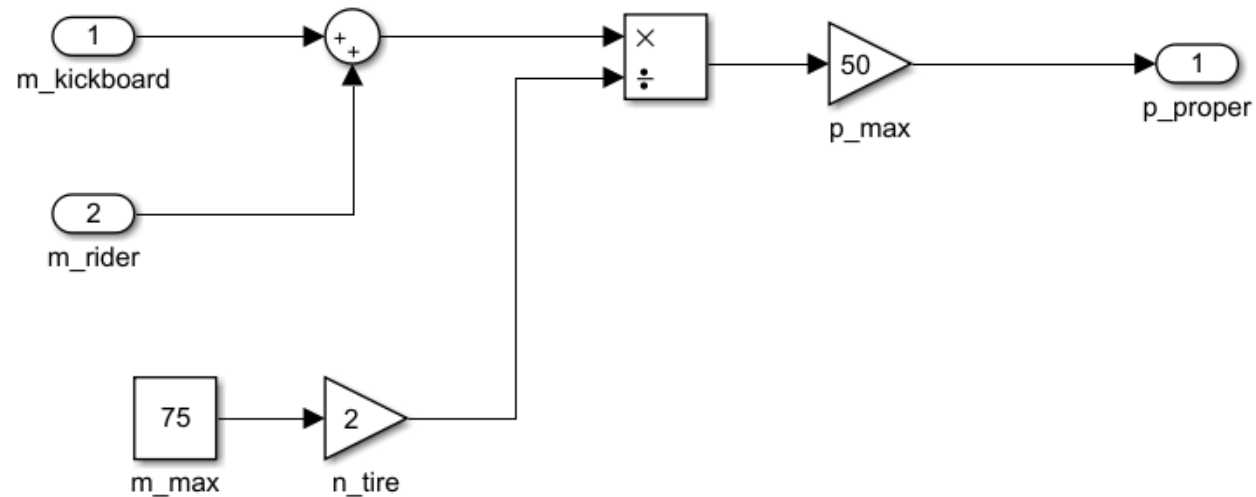
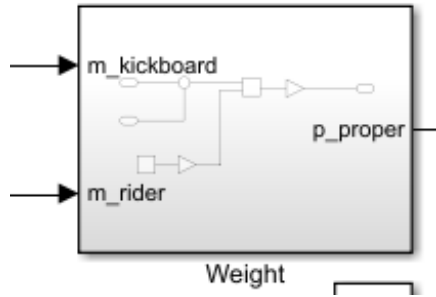
Part 4

Simulink

Part 4 Simulink



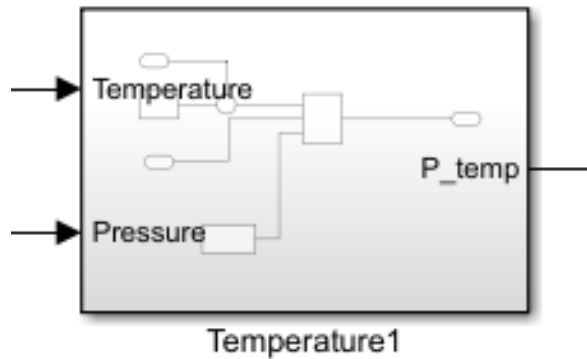
Part 4 Simulink



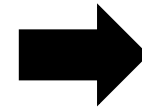
[차량총중량 / 하중지수(각 타이어*갯수)] * 100



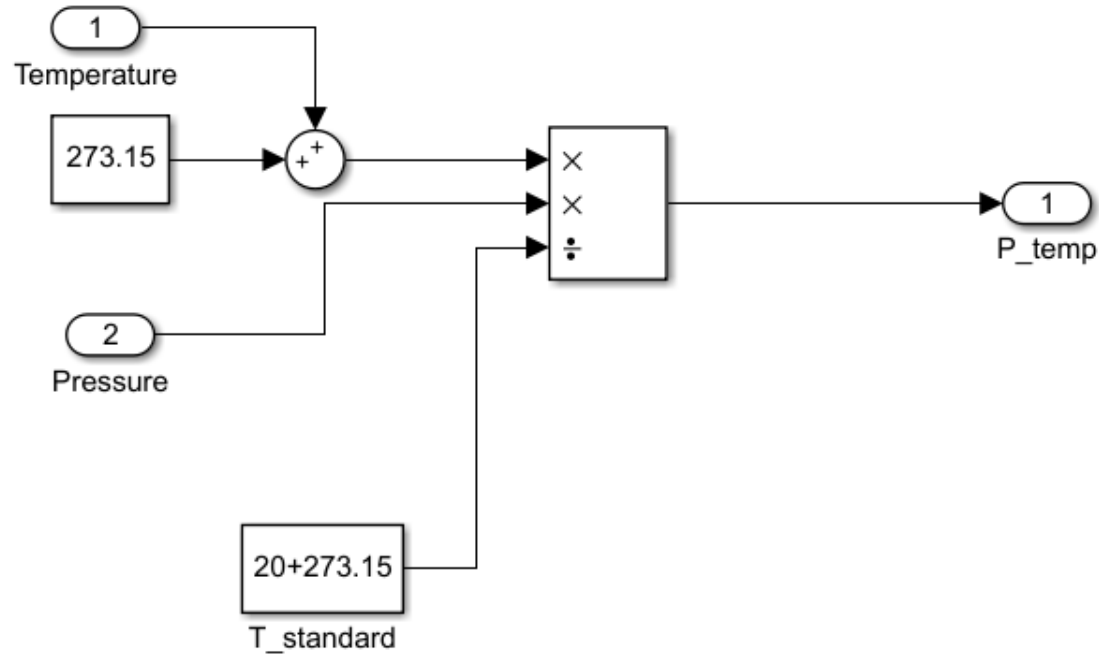
Part 4 Simulink



$$PV^n = \text{const.}$$



$$\frac{T_2 V_2}{P_2} = \frac{T_1 V_1}{P_1} \quad (V_2 = V_1)$$
$$\longrightarrow P_2 = \frac{T_2}{T_1} P_1$$



Part 4 Simulink

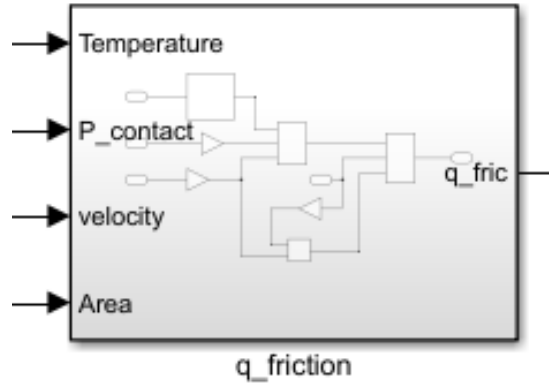
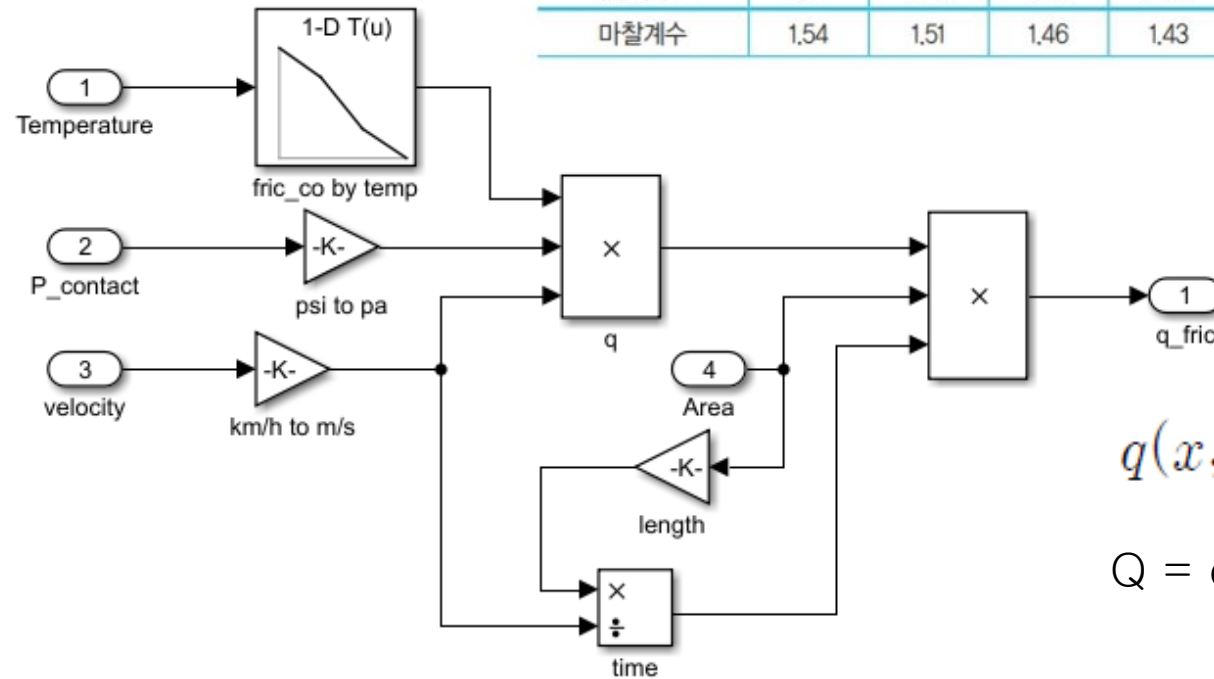


표 1. RTMS 내부온도와 고무 마찰계수 변화 경향

시험기 온도	20℃	30℃	40℃	50℃
마찰계수	1.54	1.51	1.46	1.43

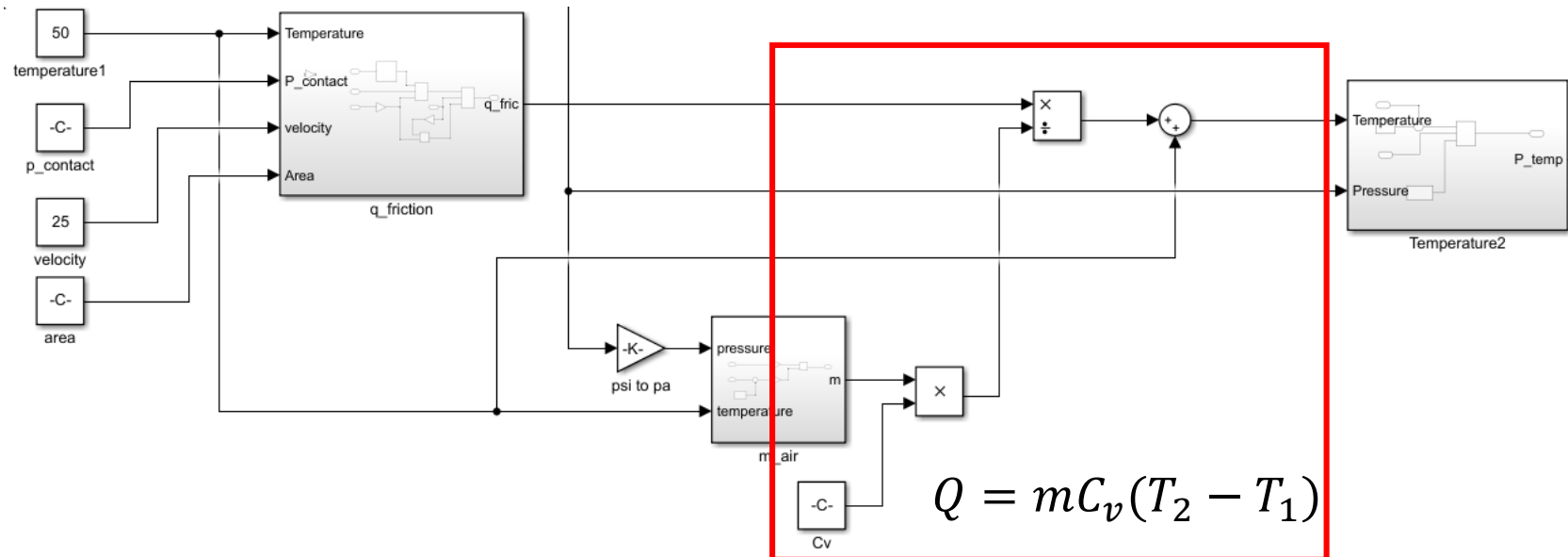
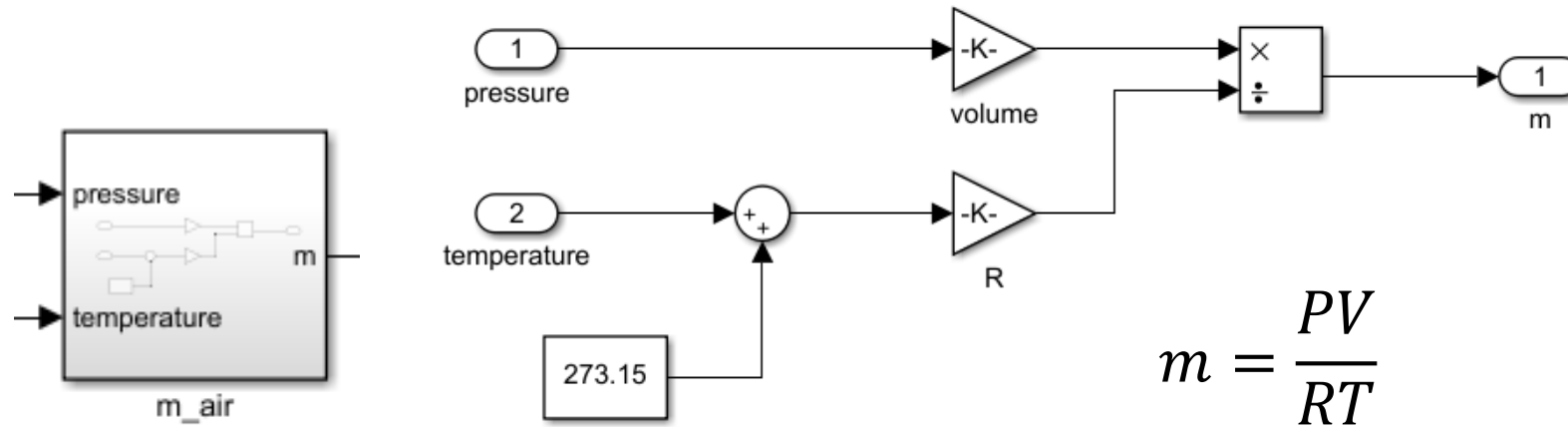
Breakpoints	Column	(1)
Row		--
(1)	20	1.54
(2)	30	1.51
(3)	40	1.46
(4)	50	1.43



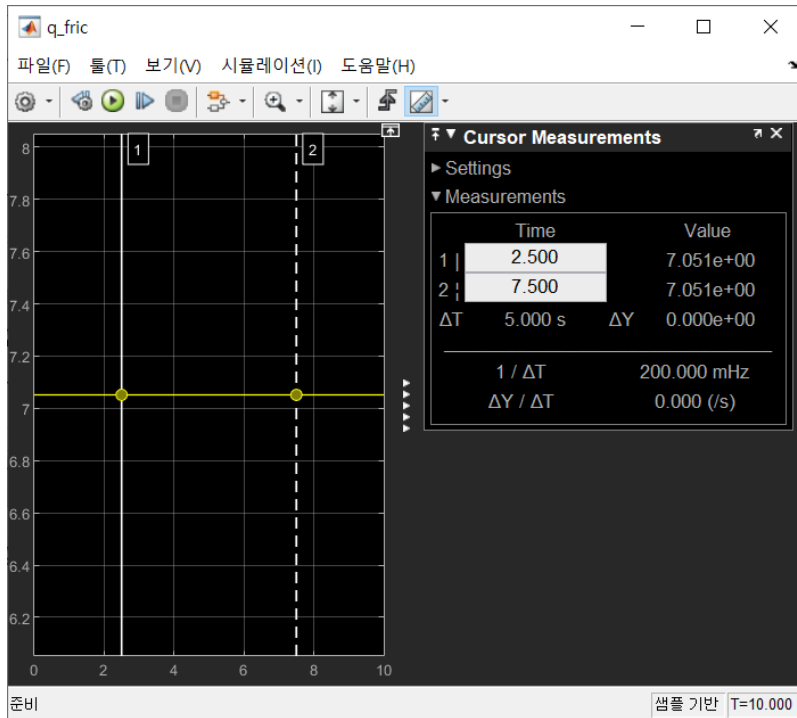
$$q(x,y,t) = \mu P(x,y)v(t) = \mu P(x,y)\omega(t)r$$

$$Q = q(x,y,t) * A(x,y) * t(t) [J]$$

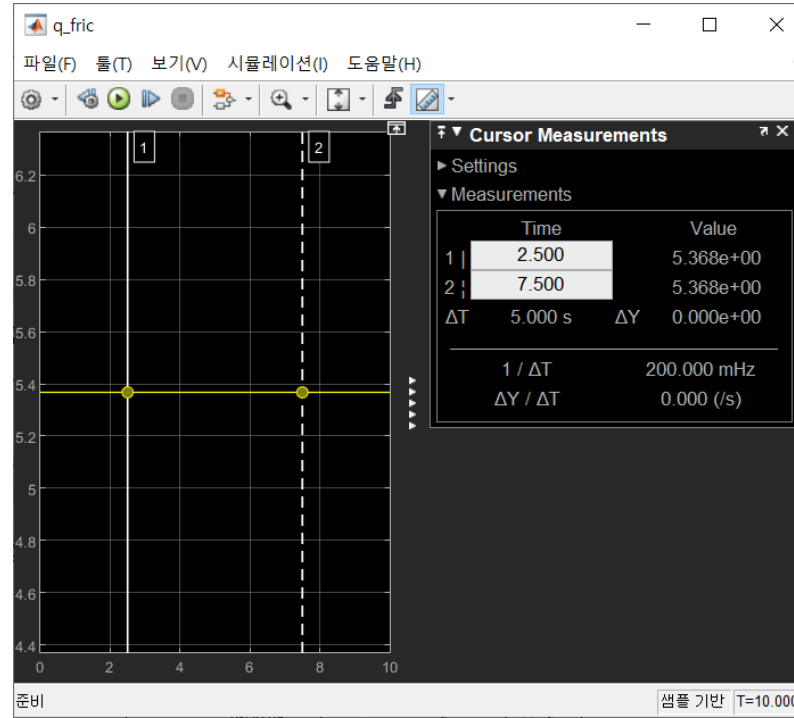
Part 4 Simulink



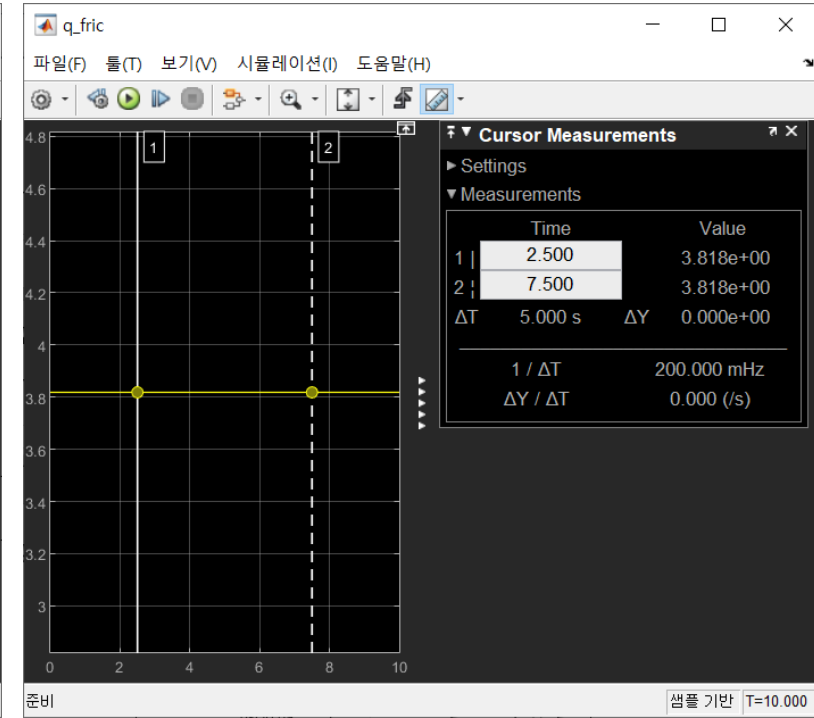
Part 4 Simulink



20psi
 $q = 7.051J$

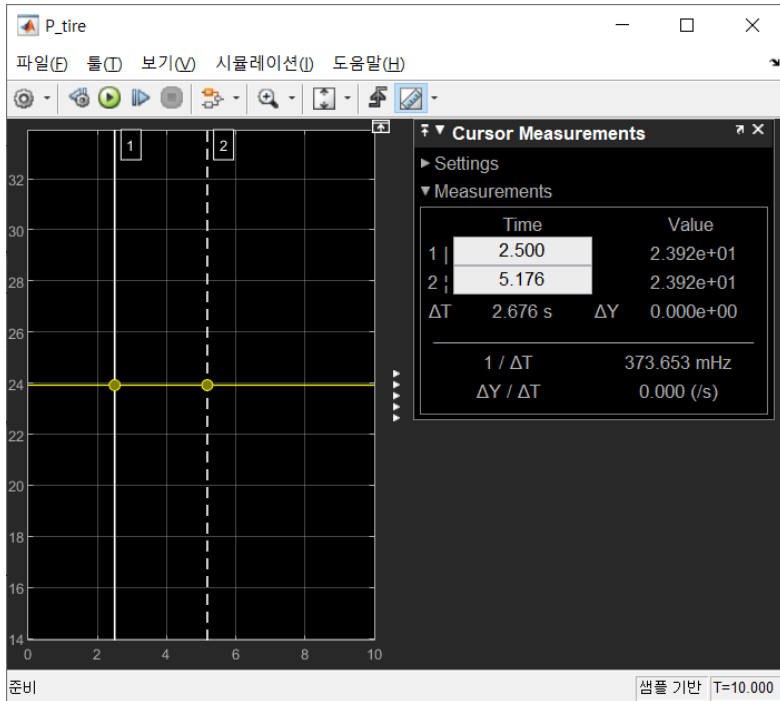


30psi
 $q = 5.368J$

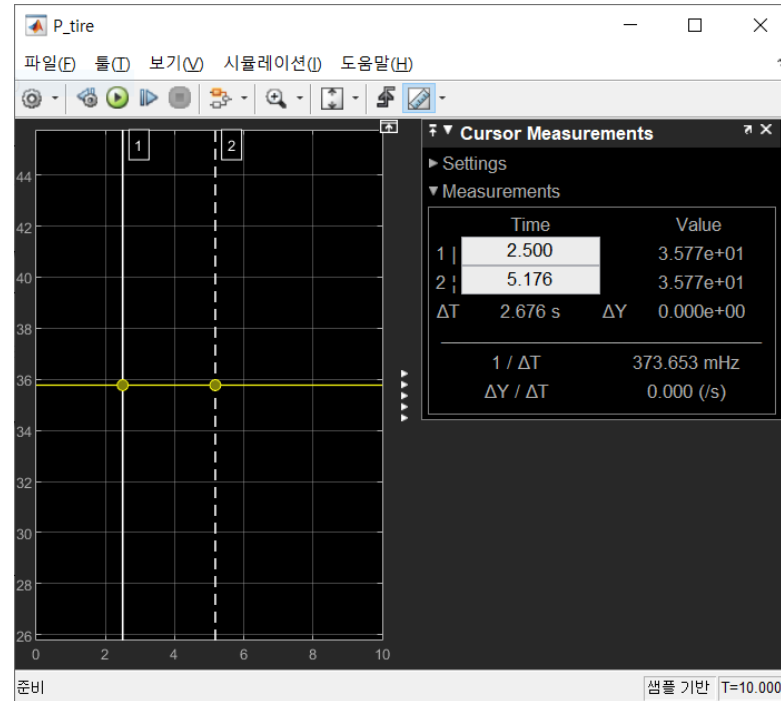


40psi
 $q = 3.818J$

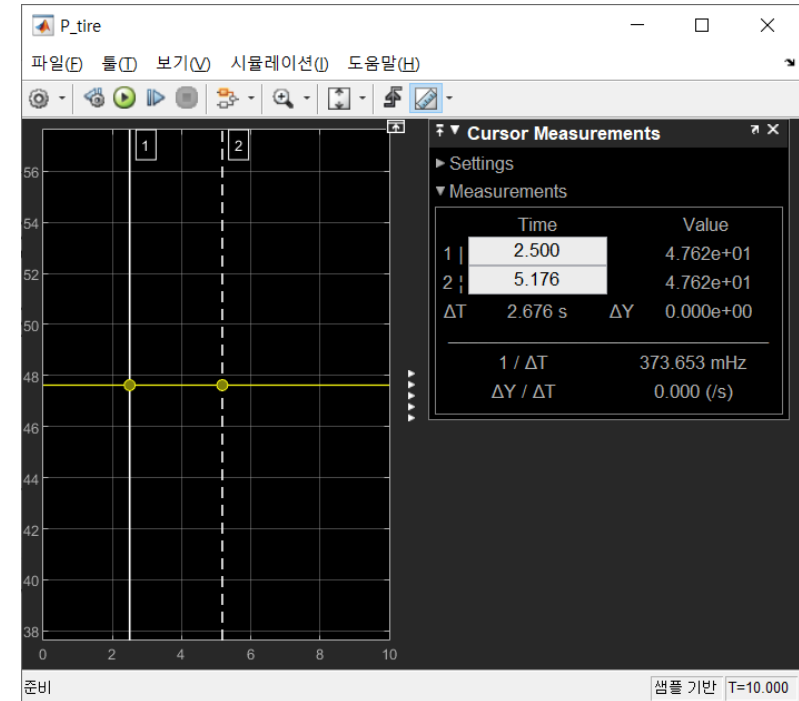
Part 4 Simulink



20psi
 $P = 23.92\text{psi}$



30psi
 $P = 35.77\text{psi}$



40psi
 $P = 47.62\text{psi}$

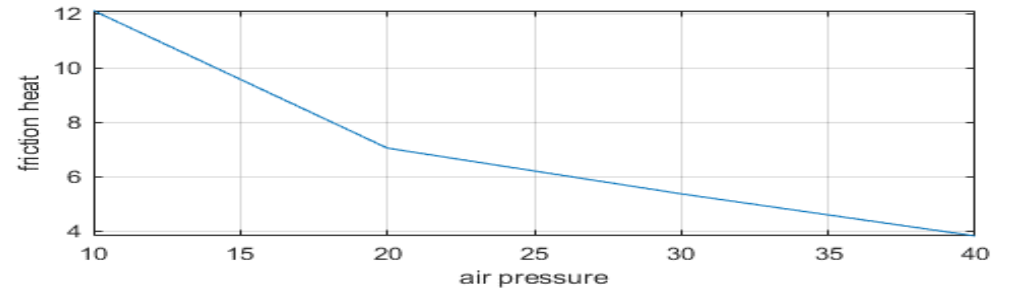
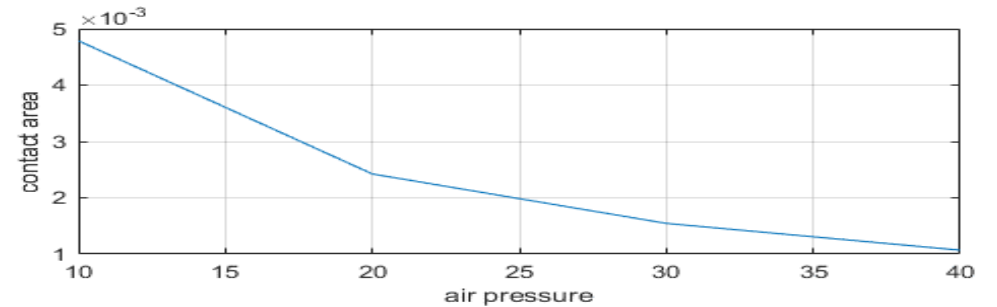
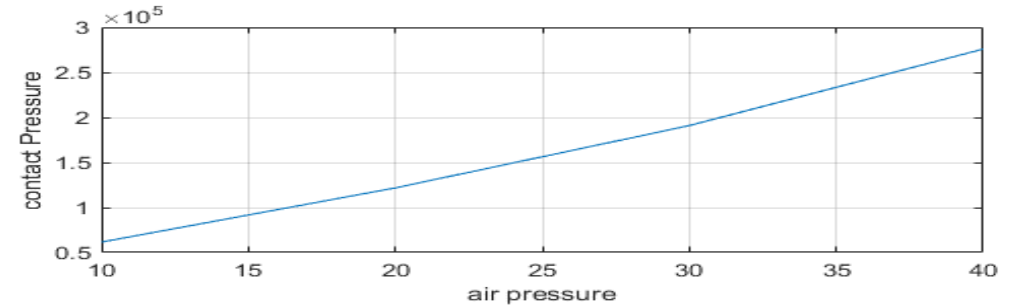
Part 5
Conclusion

결론



*공기압과 마찰열은 반비례

- 여름철 타이어의 적정 공기압보다 낮을 경우, 접촉 면적이 증가해 마찰열이 높아짐
- 적정 공기압보다 높은 공기압을 넣어줘야 함



1

타이어 모델을 단순화

2

해석 시간을 줄이기 위해서 mesh를 coarser하게 빌드

3

Simulink : 비선형 해석을 선형으로 근사

Part 5 결론 - 출처

Study for Characteristic of Frictional Heat Transfer in Rotating Brake System

- Jiwoo Nam, Hong Sun Ryou, Seong Wook Cho

Rubber Material Properties Test and Evaluation for Automobile Suspension Bush

- Changsu Woo*.Hyunsung Park

Selection and Verification of 3D Finite Element Method Model for Silicone Foot Sensor with Low Detection Pressure

- Seong Byuck Kyung*, Seo Hyung Kyu* and Kim Dong Hwan

<https://www.mi.com/global/mi-electric-scooter-pro/specs>

<http://www.bicyclelife.net/news/articleView.html?idxno=706>

<https://support.functionbay.com/ko/faq/single/88/difference-various-hyperelastic-material-models-offered-recurdyn>

http://global-autonews.com/bbs/board.php?bo_table=bd_035&wr_id=412

Thank You!

감사합니다!

