BMA4723 VEHICLE DYNAMICS

Ch3 Tire Mechanics

by
Mohamad Heerwan Bin Peeie
Faculty of Mechanical Engineering
mheerwan@ump.edu.my

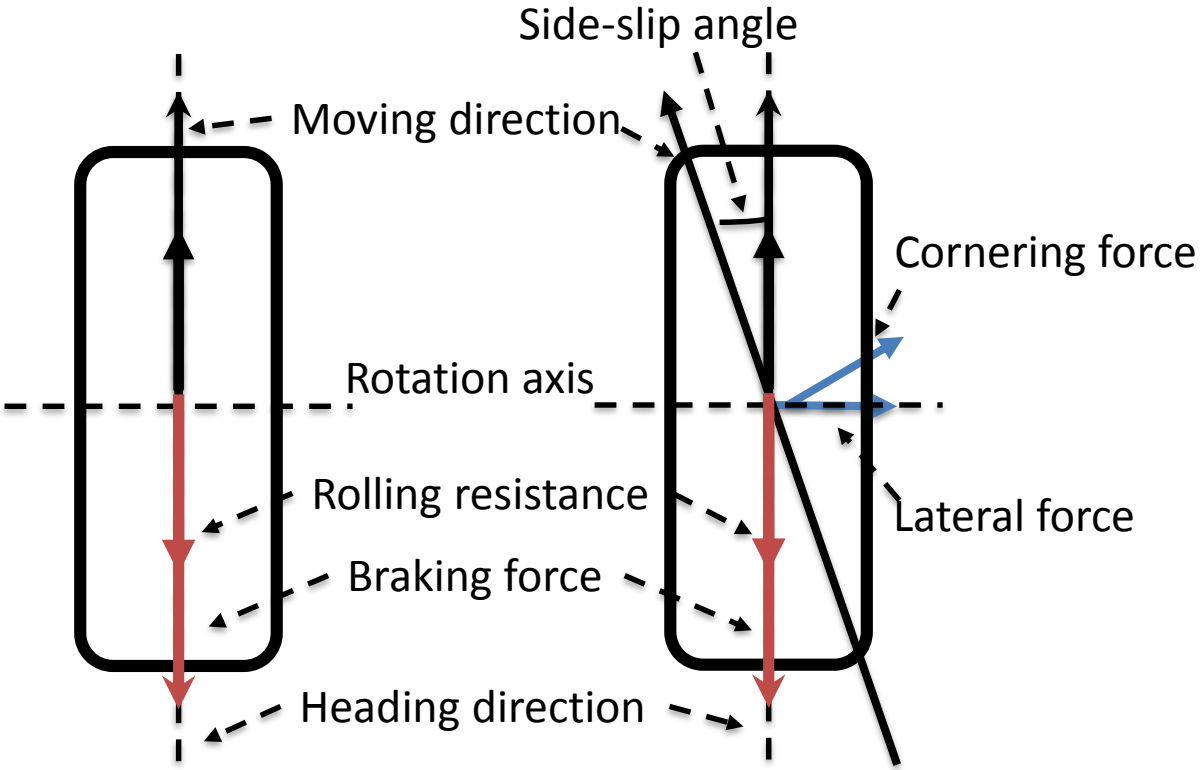
Chapter Description

- Aims
  - Explain the side slip angle of the tires
  - Explain the relation between braking and traction forces to the lateral force.
- Expected Outcomes
  - Students are able to understand the side slip angle of the tire due to the lateral force.
  - Students are able to understand the relation of the braking and traction forces to the lateral force.
- References
  - M.Abe, Vehicle Handling Dynamics Theory and Application, Second Edition, Published by Elsevier Ltd, 2015
  - Thomas D.Gillespie, Fundamental of Vehicle Dynamics, Published by Society of Automotive Engineers

Outlines

- 3.4 Side-slip angle of the tire
- 3.5 Effect of the braking and traction force to the lateral force
- 3.6 Slip ratio

3.4 Side-slip angle of the Tire



- Figure 2 The travelling direction is inline and outline of the rotational plane

3.4 Side-slip Angle of the Tire

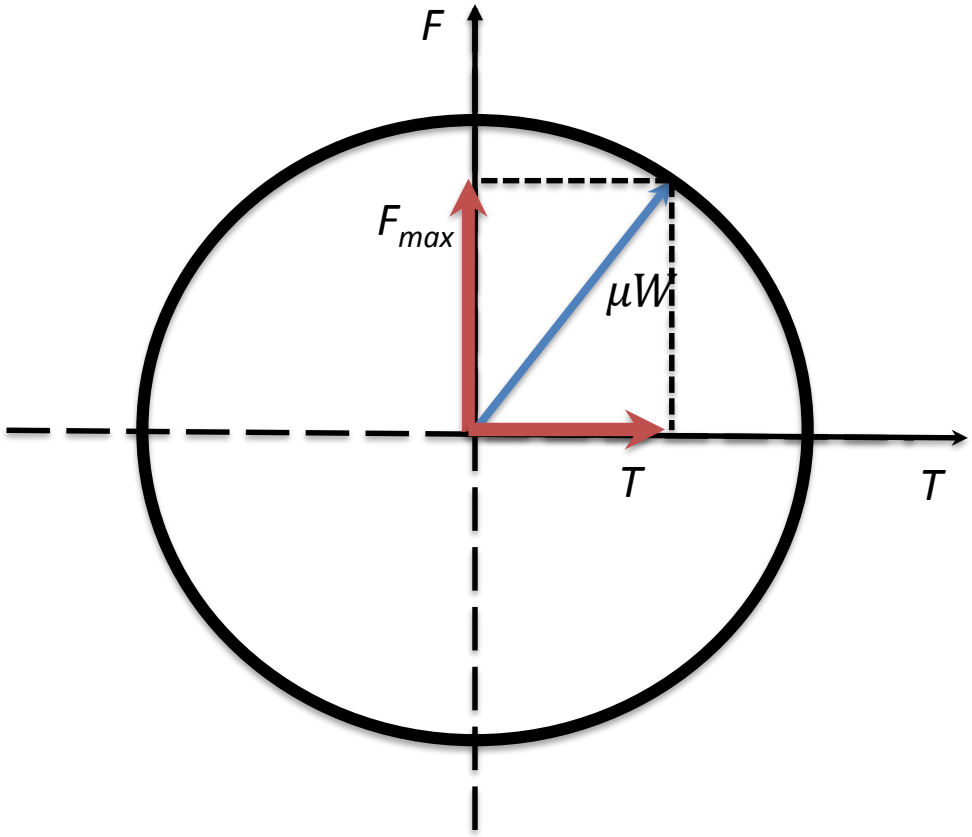
Form Fig.2:

- Lateral fore: a force that is perpendicular to its heading direction.
- Cornering force : a force that is perpendicular to the moving direction.

3.4 Side-slip angle of the Tire

- Fig.2 shows the direction of the tire with side-slip angle and without side slip angle.
- Side-slip angle is occurred when the travelling direction is not inline with the rotational plane, or its heading direction.
- When the side-slip angle is small, the lateral force and cornering force can considered as same.

3.5 Effect of the Braking and Traction Force to the Lateral Force



- Figure 2 Friction circle from the Law of Friction

3.5 Effect of the Braking and Traction Force to the Lateral Force

- Based on Fig.2, from the Law of Friction, the lateral force F and traction force T, acting on a tire must always satisfy the following equation:

$$\sqrt{F^2 + T^2} \leq \mu W \qquad \text{(Eq.1)}$$

- From Eq.1, the friction force F and traction force T cannot exceed the product of the tire vertical load and the friction coefficient μW.

3.5 Effect of the Braking and Traction Force to the Lateral Force

- By using Eq.1, the maximum cornering force F_{max} for a large side-slip angle is:

$$F_{max} = \sqrt{\mu W^2 - T^2} \qquad \text{(Eq.2)}$$

- If traction force $T = 0$, then:

$$F_{max} = \mu W \qquad \text{(Eq.3)}$$

3.6 Slip Ratio

- Slip ratio is defined as the different between vehicle actual longitudinal velocity u and rotational velocity of the tire $r\omega$.
- The equation of slip ratio is:

$$\rho = \frac{u - r\omega}{u} \text{ (braking)} \qquad \text{(Eq.3)}$$

$$\rho = \frac{r\omega - u}{rw} \text{ (traction)} \qquad \text{(Eq.4)}$$

Where:

r is the radius of the tire, and

ω is the angular velocity of the tire.

3.6 Slip Ratio

- If the vehicle is accelerating, the speed of the tire $r\omega$ is faster than the speed of the vehicle u.
- On the other hand, if the vehicle in a braking condition, the speed of the vehicle u is larger than the speed of the tire $r\omega$.
- From Eq.3, if the slip ratio is 1.0, the speed of the tire $r\omega$ is 0, and the speed of the vehicle u is not 0.
- In this situation, the vehicle is skidding.
- This phenomenon can be occurred when braking on the road with low friction coefficient such as snowy road.
- This phenomenon also can be occurred during panic braking.
- In this situation, the braking force from the driver to the tire is very large.
- Without any skid control system, the tire is lock-up and the vehicle is skidding.

3.6 Slip Ratio

- Skid phenomenon also can be happened during traction.
- From Eq.4, if slip ratio is equal to 1.0, the speed of the vehicle u is 0, but the tire is rotating.
- This situation usually occurred when driving on the road with low friction coefficient.
- The tire is rotating but the vehicle is not moving.

Conclusion of The Chapter 1

- Conclusion #1
  - The side-slip angle of the tire is occurred when the heading direction is not inline with the moving direction.
  - The braking force and traction force also can effect the lateral force.

- Conclusion #2
  - Slip ratio can be used to analyse either the tire is lock-up or not.
  - The vehicle will skidding when driving or braking on the slippery road

Vehicle Dynamics

Chapter 3

Dr Mohamad Heerwan Bin Peeie