Bicycle and Motorcycle Dynamics 2010
Symposium on the Dynamics and Control of Single Track Vehicles,
20 - 22 October 2010, Delft, The Netherlands

Study on Characteristics of Motorcycle Behavior during Braking

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Abstract

For two-wheeled vehicles behavior, it is necessary to describe the roll motion because a main centripetal force at turning is camber-thrust. Therefore, the lowest degree of freedom for two wheeled vehicle compared with the four-wheeled vehicle rises. Furthermore, as the two wheeled vehicle has unstable or less-stable characteristics, a lot of researches for two wheeled vehicle have been poured into three typical modes, capsize, weave, and wobble. However, these modes except the capsize have usually little effect to ordinary behavior of recent motorcycle under the ordinary running speed. Therefore, when we evaluate the motorcycle, sometimes, characteristics of steady state turning and reaction force of the steer bar are used for motorcycle evaluation. As the first stage, characteristics of steady state turning of two wheeled vehicle on constant radius are analyzed, and the stability factor and side slip coefficient for two wheeled vehicle are proposed as follows;

$$\frac{\delta}{\delta_0} = 1 + K_\delta v^2$$

$$\frac{\beta}{\beta_0} = 1 + K_\beta v^2$$

Here δ : Steer angle δ_0 : Geometrical steer :angle
β : Side slip angle at C.G. β_0 : Geometrical side slip angle
K_δ : Stability factor K_β : Side slip coefficient

Next, using the two coefficients, the characteristics of two wheeled vehicle during braking are analyzed using quasi steady state method. In this analysis, cornering stiffness and camber stiffness are the function of each tire load as follows;

$$F_y = K_c\phi - K_s\alpha$$

Here K_s : cornering stiffness K_c :camber stiffness
α : slip angle ϕ : camber angle

These two coefficients, stability factor and side slip coefficient are calculated as a function of longitudinal acceleration shown in fig.1. The results don't include the effect of braking forces directly. However, motorcycle has two independent or combined braking systems between front and rear, and rider can control the front and rear brake individually. For such braking action, there is a possibility that the characteristics of motorcycle changes greatly. In this analysis, it is important to use a tire model which describes a relationship between longitudinal force and lateral force on each tire. Therefore, a simple tire model, which describes the relationship, is proposed. In this model, liner tire characteristics and non-liner friction coefficient are use, and an example result of this model is shown in fig.2.

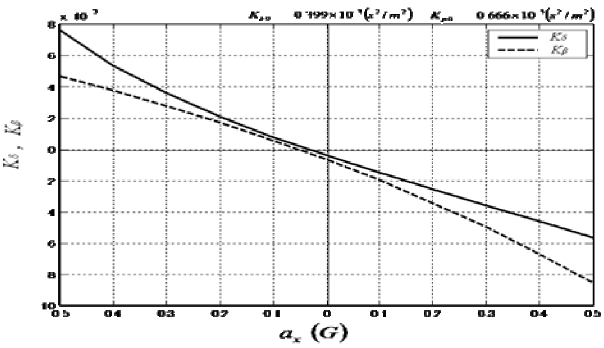

Fig.1 Coordinate System

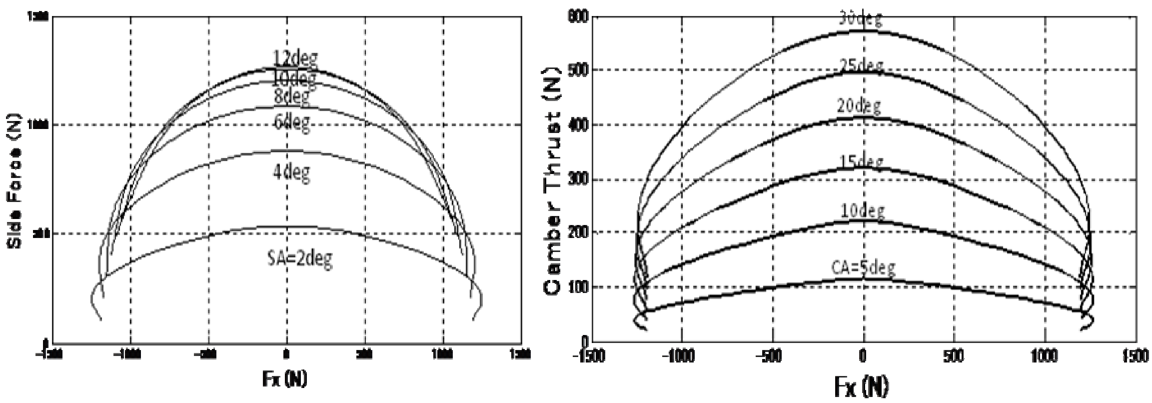

Fig.2 The calculation results of tire forces using the model

Using the tire model, the characteristics of motorcycle behavior during breaking are analyzed, especially described the effect of front and rear braking. The results are shown in fig.3. In this figure, dotted line shows non-braking and solid line shows 0.6G deceleration using front brake. In this condition, the effect of front braking is appeared just on side slip characteristics. As the characteristics of the two-wheeled vehicle at braking change depending on distribution of braking between front and rear., a detailed examination is needed from the standpoint of safety.

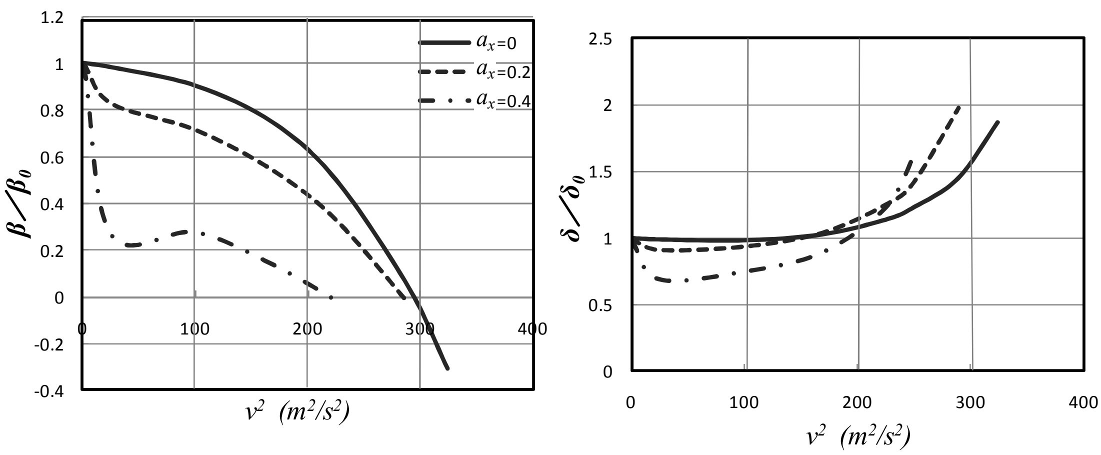

Fig. 3 The calculation results of quasi steady state turning during braking