Comparison of the Effect of Frame Damping Characteristics of Four Models on Wobble Mode of Motorcycle

Takahiko Yoshino [1)] Akira Takahashi [1)] Kenta Furusawa [1)] Tsuyoshi Katayama [1)]

1) Kurume Institute of Technology
2228 -66 Kamitsu, Kurume, Fukuoka, 830-0052, Japan (E-mail: yoshino@kurume-it.ac.jp)

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In past, Sharp reported his analysis results of straight driving stability using a 4-DOF (degrees of freedom) model. As a result of his study, there was a leap in the advancement of studies on handling stability of a two-wheel vehicle.

The study has revealed that there are three types of unstable modes by natural frequency analysis using a 4-DOF model.

More specifically, the modes are a capsize mode that comprises non-oscillatory body leaning motion; a wobble mode that primarily comprises 5 to 10-Hz oscillatory motion of a steering system; and a weave mode that comprises a coupled motion of lateral, yawing, rolling and steering systems.

From Sharp's studies, as well as a number of studies done after Sharp, it was revealed that the weave mode and the wobble mode of a two-wheel vehicle are unstable in the expressway speed range, and once the speed is higher than a certain speed, the vehicle has more chance to fall. As a matter of safety, it is necessary to stabilize those modes, and for this purpose, we need to understand how those two modes are generated. It has been believed, however, that natural frequency analysis, which has been conventionally employed, is not effective enough to reveal the mechanism of the generation.

In the 1980s, a new method - energy flow method - which enables us to understand the cause of generation of the two oscillatory modes, was proposed. According to this method, we can understand the cause of generation of the modes by computation of energy flow by the force (torque) included in an equation for the primary DOF of the respective modes.

The latest energy flow method has allowed us to obtain more detailed statistics than the method proposed about 40 years ago. More specifically, with the latest method, we can understand the reason of the change in the straight driving stability in the light of an equation of motion.

This paper examines the effects of frame damping characteristics on the wobble mode of motorcycles using vehicle specifications of four known models to understand and clarify the common results or their valid range. A 5-DOF model with frame flexibility added to the 4-DOF model was used to calculate the energy flow variation. As a result, the elements acting on the steering system in the front fork twist flexibility model are lateral acceleration force and roll rate force for the vehicle body system. In the tire system, the wobble mode is stabilized by the front tire lateral force(Fig.1). In all four vehicle types, the stabilizing effect of the front tire lateral force becomes smaller at high speeds, and the lateral acceleration force acts to stabilize(Fig.2).

The results discussed here are common to the four existing models.

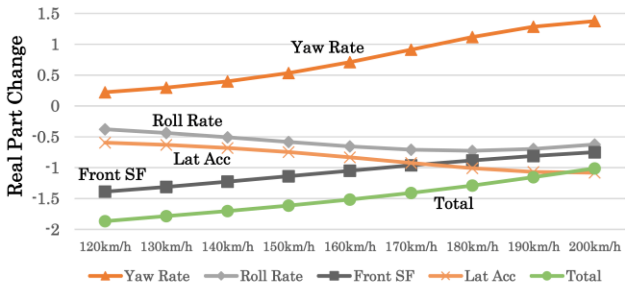

Fig.1 Eigen Value Real Part Change(Vehicle C)

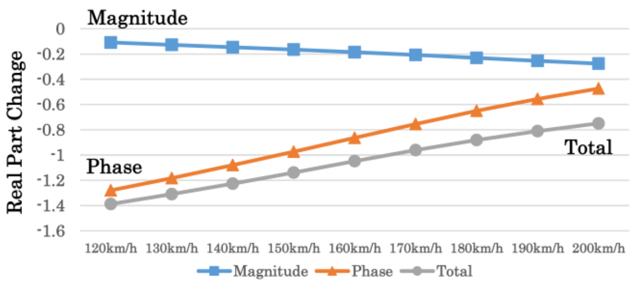

Fig.2 Front SF : Magnitude effect and Phase effect (Vehicle C)