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Formulation of Rear Frame Flexibility Model for Motorcycles

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In Japan, the Japan Automobile Manufacturers Association and the Japan Automobile Research Institute have proposed a so-called 10-degree-of-freedom model that integrates six types of frame flexibility model with the cooperation of four motorcycle manufacturers. It has been pointed out that when the frame rigidity value of this 10-degree-of-freedom model is set to infinity, there is a problem that its eigenvalues have different value of the 4-degree-of-freedom model, which is a rigid body model. It is clear that the cause of this is the modeling of the rear frame, and there is an urgent need to improve it.

The method formulated by Sharp in 1974 is used to model the rear frame in Japan. In Sharp's modeling method, the cause of the problem appears in many coefficients of the equation of motion, and it is difficult to extract the main factor.

In this paper, a new modeling method is proposed that makes it easy to extract the problem of rear frame model used in Japan. In other words, the new model proposed here shows that the cause can be concentrated on only the two coefficients of the equation of motion. It can be understood that these two coefficients are substantially the same, and therefore there is a problem with one coefficient. An illustration of the newly proposed model is shown in Fig.1. As shown in Fig. 1, the axis of yaw rotation is set at the center of mass of the mainframe in the 4-degree-of-freedom model. It is shown that this setting of the axis of yaw rotation plays an important role in solving the problem.

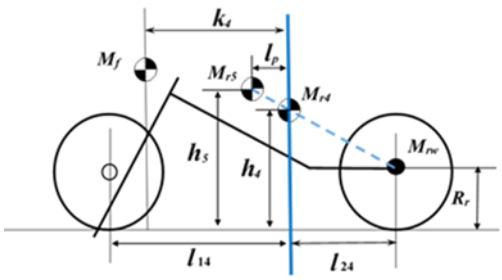
From the analysis of this problem, it is shown that the cause is due to the usage of the model developed in Japan, and if the Sharp model is followed correctly, the problem does not occur. Specifically, in Japan's model, all values of inertial products such as mainframes are set to zero. It is shown that the cause of the problem is that the inertial product is set to zero.

The inertial product of 5 degrees of freedom can be calculated, in the new model. Using the calculated inertial product value solves the problem that occurred when the frame stiffness value is set to infinity. That is, the cause that was considered to be the problem is completely offset by the effect of the calculated inertial product. The result of this calculation is shown in Fig. 2. This figure shows the eigenvalues when the inertial product is introduced. The yellow circles represent the eigenvalues when the stiffness value is set to infinity. From Fig. 2, the yellow circles show the same values as the dark blue circles, which are the values of four degrees of freedom.

The method proposed here has an advantage in practical use. Substituting the calculated inertial product value into the rear frame twist model that has been used in Japan solves the problem. This suggests that conventional models can be used for the analysis of frame stiffness effects.

Furthermore, the discussion developed here is applied to the 1971 four-degree-of-freedom model published by Sharp and the 1974 vehicle specifications, and the validity of the newly formulated model is confirmed.

That is, it is shown that the published inertial product value in the five-degree-of-freedom model can be calculated by using a newly formulated method. Furthermore, by using the value of the inertia product, it is shown that the eigenvalue when the stiffness value is infinite is the same as the eigenvalue of the 4-degree-of-freedom model.



. Fig.1 New Model for 5 Degree Rear Frame Twist

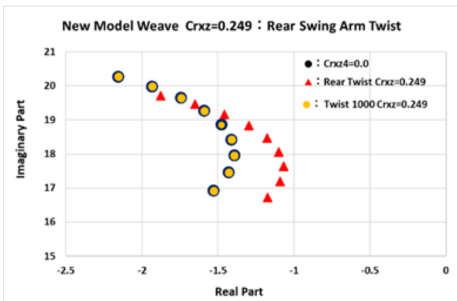


Fig.2 Root Locus of New Model for Rear Frame Twist
With C_{rxz4}=0.0, C_{rxz}=0.249

The problem of the 10-degree-of-freedom is expected to solve by integrating two new rear-frame models, a twist model and a bending model, based on the method proposed here.