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Development of tire inside contact patch measurement technology for vehicle testing

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In order to understand the vehicle dynamics, it is important to understand the tire contact forces, which is the starting point of vehicle behavior. In order not to change the vehicle characteristics due to sensors such as wheel force transducer, we tried to estimate the contact forces by embedding an ultra-small camera inside the tire and measuring the change in the contact shape of the tire inner surface. In this paper, we introduce the verification result by bench test and the vehicle measurement examples for improving vehicle performance. Fig. 1 shows the overview of the measurement system.

Fig. 2 shows the bench test result. As the bench test conditions, the tire vertical load(Fz), slip angle, camber angle assumed in the test vehicle model simulated by CarSim were reproduced. We found that the lateral and vertical deformations had a linear relationship. Also, we found that the gradient of approximate line is close to the tire stiffness value.

Fig. 3 shows the vehicle testing task called “18m slalom test”. The test vehicles are the original vehicle A and the steering performance improvement vehicle B, and their performances are compared. Fig. 4 shows the measurement results of two test vehicles. These show the changes in 4-wheel Fy and yaw rate and yawing moment with respect to steering wheel angle. The blue and red circles in the figure are the points where the calculated yaw moment peaks in each vehicle. At this time, the yaw rate is almost zero, indicating that it is the moment when the vehicle turning direction changes. In addition, the green circle in the figure is where the yaw rate is the maximum and the yaw moment is the minimum, and the yaw moments of the front and rear axles are balanced. In other words, it is a point where a steady-state circular turning. Fig. 5 shows a diagram of the occurrence of 4-wheel Fy and yawing moment. We found that the vehicle B is smaller in the rear wheel Fy caused by the vehicle body slip before turning the steering from right to left. Therefore, the yawing moment on the front axle required to change the turning direction of the vehicle becomes small, and the steering wheel angle also becomes small. Therefore, We found that it is important to quickly shift the remaining lateral force of the rear tire before to the next steering direction.

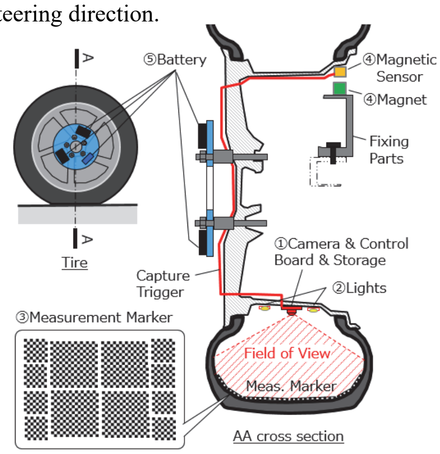

Fig. 1 Measurement system

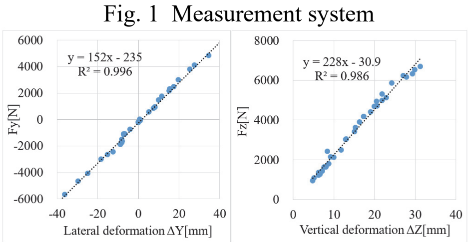

Fig. 2 Tire Fy and Fz vs Inner Deformation

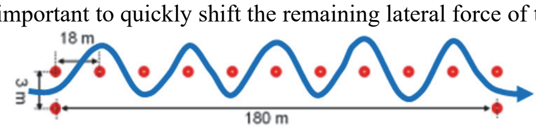

Fig. 3 18m slalom test

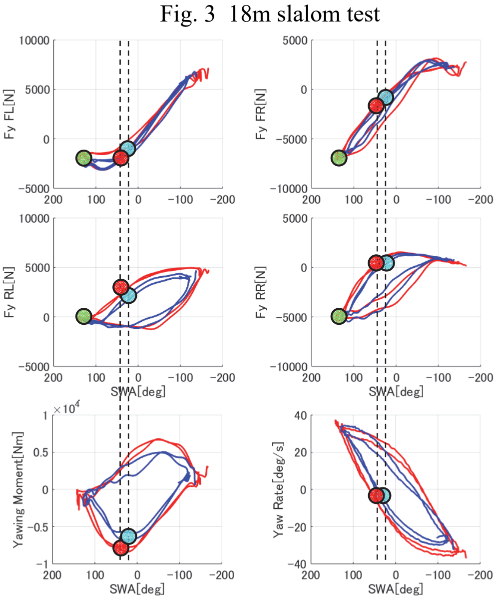

Fig. 4 4-wheel Fy and yaw movement vs steering wheel angle

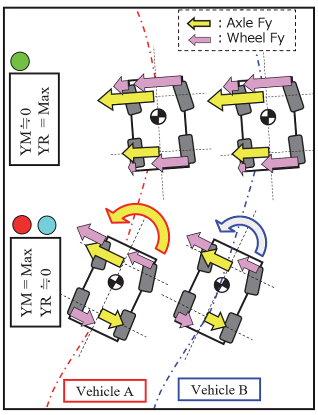

Fig. 5 Image diagram of 4-wheel Fy and yawing moment