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Study on Mechanism of Lateral Force and Tread Deformation in Contact Patch of Rolling Tire

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Cornering stiffness is a key tire unit characteristic for consideration of automobile maneuverability. With the evolution of automobiles such as automatic driving vehicles and electrification, a method of examining tire specifications that provide appropriate cornering stiffness suitable for the vehicle will also be an indispensable tire design technology going forward. Examination of specifications for achieving the target cornering stiffness calls for a physical characteristics tire model that determines the causal relationship between the lateral stiffness of each tire part and the cornering characteristics. However, highly accurate and simple modeling of the tread part has been an issue for achieving this. The TM tire model is a physical characteristics tire model devised to address that issue (Fig. 1).

The features of the TM tire model are classification of the tread part into two types of elements, one with stiffness that changes in proportion to the square of the contact patch length and one with stiffness that changes in proportion to the contact patch length, and expression of the relationship between the lateral force generated on the contact patch and the deflection. However, the results of existing research show that a more complex phenomenon occurs in the tread part of the contact patch of an actually rolling tire. Thus, there are unclear points as to why the simple concept of using two types of elements to approximate a complex phenomenon can achieve high approximation accuracy and in the details of the mechanism, and so it has remained a hypothesis. Therefore, the purpose of this study was to observe in detail the forces and deformation occurring on the contact patch with a measuring apparatus and to conduct experiments to directly verify the reasonableness of the approach to modeling the tread part. The specific goal was to compare the results of simulation by an FEM model (Fig. 2), which modeled each part of the tire in detail, with the data obtained by directly measuring the lateral force Fy generated on the contact patch when rolling using a tire dynamic surface pressure drum tester (Fig. 3), and to clarify the mechanism of the relationship between the deformation of the contact patch tread part and the lateral force. Figure 4 shows an example of visualizing and comparing the simulation results by the detailed FEM model and the measurement results by the dynamic surface pressure drum tester. The results of detailed comparative analysis showed that similar characteristics, such as the distribution of the lateral force generated within the contact patch and the deflection can be confirmed in both data, and it was verified that the results predicted from simulation by the detailed FEM model matched the experimental results by the measuring apparatus.

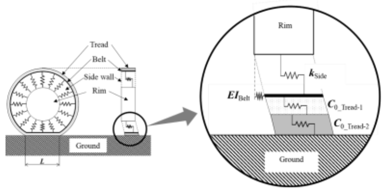

Fig. 1 Concept of TM tire model.

This verification proved that the FEM model reproduces the actual tire tread part with sufficient accuracy. That is to say, as the validity of the TM tire model concept has been proven using this same FEM model in existing research, this study was also able to prove experimentally the validity of the tread part model concept of the TM tire model for the first time known to date.

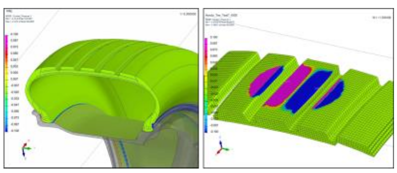

Fig.2 Simulation by FEM Model

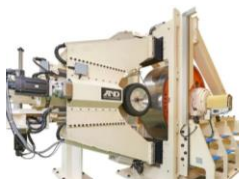

Fig.3 dynamic surface pressure drum tester.

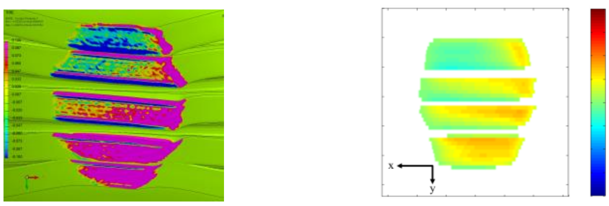

Fig.4 Graph comparing simulation results by FEM Model and measurement results by dynamic surface pressure drum tester.