Development of Analysis Method on Rail/Wheel Rolling Contact by Large-Scale Parallel Computing

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Abstract

The deterioration of the rail and the wheel, such as wear and a crack, leads to various unfavorable phenomena and problems like the environmental noise and the degradation of riding quality. It also causes the decrement of running safety and running stability, which sometimes leads to a serious accident.

Contact between the rail and the wheel takes place in such a very small area as a circle of less than about ten centimeters radius, called "contact patch" . At the contact patch, the rail and the wheel are exposed to a large running impact load producing a high frequency vibration of the order of kHz. There also appear microscopic mechanical behaviors like relative slips. Though these physical phenomena being considered as factors giving rise to the deteriorations, the detailed mechanisms of their initiation and progress have been unsolved. One of the reasons is that there are hardly any experimental methods available for evaluating the contact patch under the running train vehicle. Therefore, numerical simulation has been applied as a feasible method for its investigation. But due to the limitation of computing power, many studies have been limited to simulations on the elastic and static contact problems so far.

In our study, a dynamic rolling contact analysis method was developed based on three-dimensional finite element structural analysis software FrontISTR. In the present analysis, the axis is loaded with torque and the dynamic behavior of the rail and the rolling wheel is simulated. The contact problem is solved by Lagrange multiplier method. For the execution of the analysis program, we use the FE model based on the same shape and the same material constants as Shinkan-sen for both the rail and the wheel. As mentioned above, the contact patch is quite a small area, which requires the mesh size to be smaller than 1 mm near the contact surface for the accurate evaluation. On the other hand, the size of wheel and the rail are relatively large to it, resulting that the size of FE model reaches 10 million DOF. By utilizing the Earth Simulator, two different large-scale simulations are conducted. One was static contact analysis by loading the wheel load, which aims to verify our FE models. The other was the dynamic rolling contact analysis between wheel/rail. In this paper the results obtained from these two simulations are reported.

Keywords: Large-scale simulation, Three-dimensional FEM, Dynamic rolling contact, Railway