STUDY ON THE WEAR OF WHEEL FLANGE/RAIL GAUGE FACE

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ABSTRACT
This paper describes the measured results of an actual worn rail, stress analysis of wheel/rail corresponding to a real contact, and laboratory test results of wear simulation. In the research the worn rail in sharp curved track was investigated through residual stress measurements and micrographic observation. The contact stresses of wheel/rail were estimated with a three-dimensional FEM elastic-plastic model to study the effect of applied loads and contact geometry on wear progress of wheel and rail. The experimental wear simulation by using a large rolling contact machine has been carried out to estimate the actual wear of wheel/rail, and clarify the influence of material hardness and contact geometry on wear of wheel flange/rail gauge face.

1. INTRODUCTION
For curved tracks, the wear of wheel flange and rail gauge face is one of major factors in vehicle/track maintenance cost. In order to reduce the wear of wheel flange and rail gauge face, some maintenance technologies such as lubrication and grinding are generally adopted. Over the years, the wear of wheel/rail has been extensively studied, by aid of field investigation [1] and laboratory experiments [2], and also many wear modes and corresponding mechanisms have been discussed [3]. However, it is still difficult to correlate the laboratory results and those obtained from field investigation clearly. The present work is how to attempt to use some laboratory simulation tests for predicting the wear of wheel/rail. It is expected that wear tests in laboratory will simulate the actual contact of wheel/rail.

2. INVESTIGATION OF ACTUAL WORN RAIL
Fig.1 shows the worn amount of an outer rail at renewal time. The maximum wear amount at gauge corner is about 13mm while the wear amount at railhead shows only 1.5mm.

Fig.2 shows the measurement results of residual stresses. The measured position is illustrated in the figure. The residual stress reaches about 500MPa at gauge corner. This is 2.5 times higher than the residual stress (200MPa) at railhead. It is implied that the gauge corner of the rail had a severe stress state, which led to larger plastic flow and work hardening than the railhead.

To investigate plastic flow and material hardening in worn and deformed surface layer, the micrographic characteristics of the rail on the longitudinal section were observed by an optical microscope. The results, as shown in Fig.3, disclosed significant differences of plastic flow layers between at gauge corner and at gauge head. At the gauge corner, as shown in Fig.3 (a), a heavy plastic flow was formed and many micro-cracks reaching a length of 0.5-3mm were found in the subsurface layer parallel to the plastic flow trace. At the railhead, as shown in Fig.3 (b), only a relative light plastic flow was observed, and it has a flow direction opposite to that shown at the gauge corner. This phenomenon is caused by different tangent forces due to varying wheel diameter at contact position.
wear amounts of the rail disc and the wheel disc are the values at wear cycles of $30 \times 10^5$ and $21 \times 10^5$, respectively. In the figure, the gauge face wear of the rail disc decreased significantly with the hardness increase of the rail disc under the condition of a constant hardness of wheel disc. In the same time, as the counterpart of the rail wear, the wear of the wheel flange did not show a trend of increase, but decreased also. The reason resulting in this phenomenon is believed to be that the increase of the rail hardness limits its profile change in a very narrow range and keeps the contact at the position with a low slip ratio. In addition, the wear of wheel disc was far lower than that of rail disc because the wheel disc was set as driving side.

5. CONCLUSIONS
(1) For actual worn rail, the gauge corner and the railhead have a significant difference in the residual stress and plastic flow. The gauge corner shows a larger residual stress and a heavier plastic flow than the rail head, which verifies that the gauge corner is subjected to a more severe stress state than the railhead.
(2) The contact of the wheel/rail has been simulated. The results show that the stress state depends on the applied load and the profiles of the wheel and rail. The worn profiles may result in the severe contact, trending to accelerate wear progress.
(3) Increasing the initial hardness of rail disc can improve the wear resistance of wheel flange/rail gauge corner. The wear of wheel flange depends on the profile variation of the rail as its counterpart.

REFERENCES