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Application of Synchrotron Radiation to Study Rolling Contact Fatigue of Railway Rails

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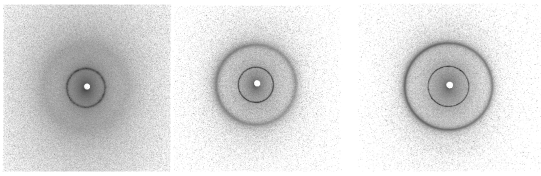
Introduction

Fatigue cracks grow in almost railway rails during service due to the repeated passage of trains over the rails through the contact of heavy and rolling wheels of trains. In order to avoid rail failure from these cracks, rail testing schedule is important to find rail defects for proper remedial actions. An engineering model has been proposed to predict crack growth rate in rails based on the fracture mechanics. Residual stress is one of the most important components that acts in rails to affect crack growth.

It is known that the removal of damaged layer by grinding is effective for decreasing generation of rail defects in case of JR-Shinkansen Line. However it is not clear that grinding of rail head is also useful for more low speed railway lines. This is because the residual stress patterns formed in the surface layer of rail head are much deeper than those of high speed railway lines like the JR-Shinkansen Line.

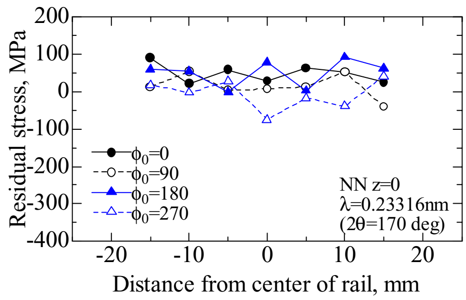
In order to study on the effects of grinding for rail defects, residual stress measurements were conducted for different grinding conditions. In this study, residual stresses in test rails used for the JR-Yamonote Line were measured with the method of X-ray stress measurement using synchrotron radiation. The distributions of residual stresses at the surface layer of the rail head were investigated with nondestructive method using different wave length of synchrotron radiation. Four types of rails, of which grinding conditions were different each other, were compared. It was found that the tensile residual stresses were built up at the gage-side surface of the ground rail, and that the triaxial stress state was formed in rail head surface after grinding. The triaxial stress analysis was also performed using an image plate type X-ray stress measurement.

Fig.1 shows examples of Debye-Scherrer rings obtained from rail used in service for about six years. The penetration depth for each experiment was different each other, which enables us to know the depth profile of residual stress in rail. Fig. 2 shows the results of the stress measurement. It shows that stress gradient is build up in surface layer of rail.

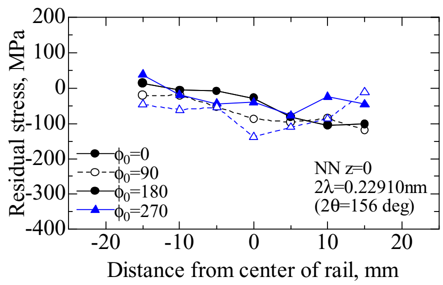


(a) λ=0.23316nm (b) λ=0.22910nm (c) λ=0.21993nm

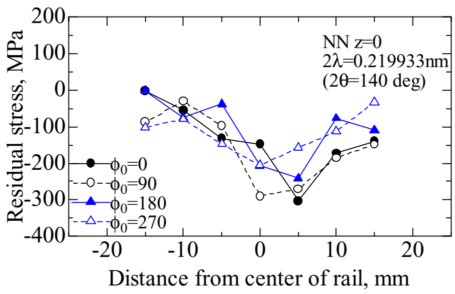
Fig.1 211-Debye−Scherrer rings obtained from NN-rails using synchrotron radiation.



(a) λ=0.23316nm



(b) λ=0.22910nm



(c) λ=0.21993nm

Fig.2 Result of biaxial residual stress analysis using synchrotron radiation

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