Materials Science

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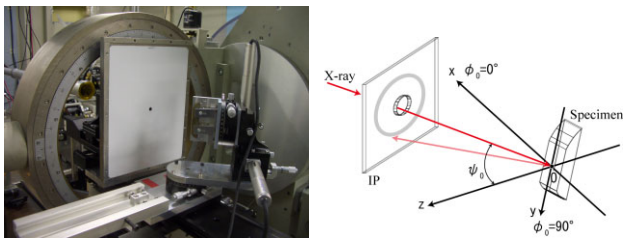
STRESS MEASUREMENTS BY SYNCHROTRON RADIATION FOR RAIL SURFACES DAMAGED BY ROLLING CONTACT FATIGUE

Toshihiko SASAKI[1] and Syunichi TAKAHASHI[2]
[1]Kanazawa University, Kakuma-machi, Kanazawa, Ishikawa, 920-1192 Japan
[2]Graduate School of Kanazawa University, Kakuma-machi, Kanazawa, Ishikawa, 920-1192 Japan

In the field of railway technology, there is a problem known as rolling contact fatigue (RCF) in rails. It is necessary to elucidate the mechanism of the initiation and the growth of the RCF cracks in order to prevent unexpected accidents caused by this phenomenon. Hirakawa reported that residual stress plays an important role in the behavior of cracks in the rail. However, residual stress in rails is one of the most unknown parameters in the RCF phenomenon.

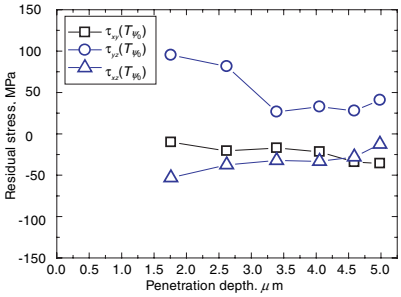
In this study, the authors tried to clarify how RCF contributes to the residual stress state in the surface of the rail head by using X-ray stress measurement. The ordinary X-ray stress measurement method enables us to give mean stresses averaged over the penetration depth of X-rays. However, it is difficult to elucidate the depth profile in areas less than approximately 5 μm. The purpose of this study is to evaluate the depth profile of residual stresses within such thin surface layers of the sample by an area detector type X-ray stress measurement. In this study, optimum conditions for this purpose were chosen by means of synchrotron radiation, and the measurement depth was controlled by the incident angle of the X-ray. Thus, the Laplace stresses, the mean stress within the penetration depth of the X-rays, were determined from a rail sample with an area detector. Next, the depth profiles of the real space stresses were presumed from those of the Laplace stresses obtained. Triaxial stress analysis at the surface layer of a used rail was conducted with an area detector by this method.

Fig.1 shows experimental set-up for stress measurement used in this experiment which is based on the use of an image plate two-dimensional X-ray detector. Fig.2 shows a result of the measurement showing residual stress distribution of rail surface in depth direction.

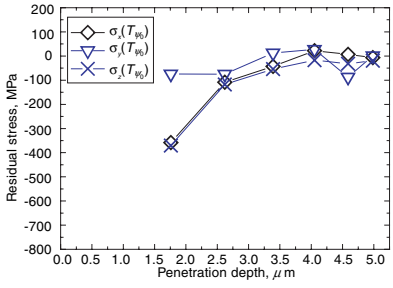


(a) (b)

Fig. 1 Experimental setup for area detector type stress measurement by synchrotron radiation. (a) Experimental setup. (b) Measurement optics.



(a) Shear stress on position 1.



(b) Normal stress on position 1.

Fig. 2 Measured stresses obtained from different locations.

sasakit@kenroku.kanazawa-u.ac.jp