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Influence of Diffraction Angle on the Area Detector Type X-ray Stress Evaluation Through Synchrotron Radiation (2^{nd} Report)

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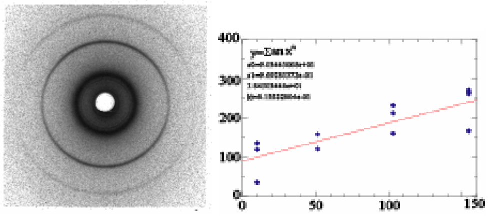
This is our second report on a new type of the X-ray stress measurement method (the area detector type X-ray stress evaluation method , AD/cosα method), in which an area detector such as an Image Plate and the cosα method as a stress-converting principle are combined. The method has some expected advantages compared with the ordinary X-ray stress measurement method. The use of synchrotron radiations will enable to perform the materials evaluation for much variable materials with higher accuracy and efficiency. For example, the measurement at the high diffraction angle such as $2\theta > 170°$ will be possible. The measurement with this range of the diffraction angle has been thought to be impossible with the ordinary X-ray method up to now because the diffraction beams are generally interrupted by a part of the instrument used. However, it is known that the precision of the X-ray stress measurement increases with 2θ and , therefore, the range of $2\theta > 170°$ is the most desirable condition. Since the optics for the AD/cosα method is so simple that nothing cuts diffraction beams, we can realize the measurement in this hopeful condition. In order to confirm these expected possibilities, the experiment was performed with synchrotron radiations with PF at KEK. It was also investigated to elucidate the relationship between the precision of the AD/cosα method and the diffraction angle under some wave lengths.

The experiments were made using the BL-3A of the Photon Factory at KEK. A steel plate (JIS S55C) was used as the specimen. The principal diffraction conditions were as follows; the wave length of 0.233 nm ($2\theta = 170°$), 0.209nm ($2\theta = 156°$) and 0.209nm ($2\theta = 127°$) were used. The incident angle of the beam onto the area detector was 30°. The applied strains given to the specimens were up to 1000×10^{-6}. The image data stored in IP were read with the IP reader (Fuji Film BAS-2000) under the condition of Latitude=5, Sensitivity=10000, Resolution=100μm. The diffraction profiles in radius direction were calculated from the diffraction image with 1° interval of the central angle. Then, 360 diffraction peak locations were determined for each diffraction image using the half-value breadth method. They were then converted to the lattice strains using the Bragg's condition with non-strained diffraction data. The stresses within the material were obtained from each diffraction image with the cosα method using Young's modulus, Poissson's ratio,a supplementary angle of 2θ and an incident angle of X-ray.

Figure 1(a) shows an example of the diffraction ring obtained from the experiment. Figure 1(b) shows the relation between measured and applied stresses.



(a) Debye-Scherrer ring (b) result of stress obtained

Fig.1 211 diffractions at and stresses obtained with the condition for $2\theta = 156°$

After comparing the data scattering, we saw that the precision of the stress measurement is not improved with the diffraction angle as expected before the experiment. The order of the reliability was 156° , 170° and 127° in better order. This would be because there are some negative factors for stress measurement in high 2θ condition, such as the increase of the full width at half maximum, the decrease of the range of the orientation of the strain used for the stress determination, and low diffraction intensity due to the longer optical path length.

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