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Measurement of stress distribution ahead of single edge notch by imaging plate

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Introduction

Metal matrix composites have several advantages in structural applications such as high specific stiffness and strength, and high wear resistance 1]. Because of these advantages, they are expected to be new structural materials in aerospace and automobile industries. For the structural materials, the fatigue strength is the most important factor to ensure a long-term reliability.[2,3] Especially, the evaluation of the fatigue damage is indispensable to assess a remaining life. Since the X-ray diffraction method can detect the stress state in the composite materials nondestructively, the X-ray method is promising for evaluation of the fatigue damage. Since fatigue of engineering components usually originates from notches or other stress concentrations, stress state in a local area must be evaluated.

In the present study, stress distribution ahead of a single edge notch in the ultra-fine grained steel was measured by using an imaging plate to establish the local stress measurement method.

Experimental procedure

Material and specimen

The material used is a rolled steel plate with ultrafine-grained surface layers, called SUF plates, exhibit excellent crack arrestability. The average grain size perpendicular to the rolling direction is about 2 μm. The smooth and notched specimens were prepared by an electron discharge machine. The specimens have a width of 10 mm, a length of 70 mm and a thickness of 2 mm. A single edge notch is introduced by an electron discharge machine. The notch depth and the radius of the notch tip are 1 mm and 0.16 mm, respectively. The surface of the specimen is polished by emery sand papers and finally finished by an electro polishing before stress measurement.

X-ray stress measurement

The stress measurement by using synchrotron radiation was conducted at the beam line 3A of PF. The wave length of the X-ray used was 0.22804 nm. The Fe 211 diffraction was used for stress measurement. The stress distribution was determined by the cosα method [4] by using an imaging plate. The collimator used was a 0.1 and 1.0 mm in diameter. The angle of ψ_0 was 30 deg. The condition of stress measurement was summarised in Table 1. The diffraction elastic constant was determined by the smooth specimen under applied loading.

Table 1: X-ray diffraction conditions

Wave length (nm)	0.22804
Diffraction line	Fe 211
Diffraction angle, 2θ (deg)	154
Collimator (mm)	0.1, 1.0
Camera length (mm)	80
Incident angle, ψ_0 (deg)	30
Exposure time (sec)	600, 20

Results and discussion

Diffraction elastic constant

The elastic constants obtained for the collimator size of 1.0 and 0.1 mm were E/(1+ν)=182.7 and 185.7 GPa, respectively. These values agree very well with the standard value of 175 GPa.

Figure 1 shows the stress distribution ahead of the notch. In the figure, the solid curve indicates the result calculated by FEM. The stress distribution ahead of the notch was successfully measured by the cosα method.

References

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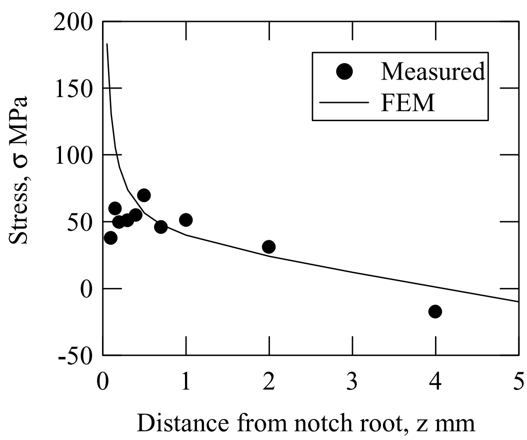

Fig. 1. Stress distribution ahead of notch.

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