Unstable Crack Propagation of Automobile Advanced High Strength Steels

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1. Introduction

Recently, Advanced High Strength Steels (AHSSs) have been widely applied to the body parts in automobile industry. AHSSs have high tensile strength but poor ductility. Many researches about the fracture prediction of AHSSs have been carried out and the prediction scheme for crack initiation around stress concentration area based on numerical simulation have been successfully developed [1]. However, for higher strength steels which have tensile strength of more than 1000 MPa, the ductile fracture criteria have not been established yet, because of ductile-brittle transition during crack propagation. Therefore, in this study, the crack propagation behavior of AHSSs were observed and, based on fracture mechanics, the critical stress intensity factor of unstable crack propagation was identified.

2. Experiment

In this study, commercially available AHSSs of JSC1180 grade (Thickness: 1.2 mm) was used as a specimen. Geometry of single edge notched tensile (SEN(T)) specimen is shown in Fig. 1. The radius of initial notch tip is 0.5 mm and fatigue crack was introduced before tests. Stress intensity factor of SEN(T) specimen was calculated from,

$$K_{\mathrm{I}} = \frac{P}{B\sqrt{W}} f\left(\frac{a}{W}\right) \quad (1)$$

$$f\left(\frac{a}{W}\right) = \frac{\sqrt{2\tan\frac{\pi a}{2W}}}{\cos\frac{\pi a}{2W}}\left[0.752 + 2.02\left(\frac{a}{W}\right) + 0.37\left(1-\sin\frac{\pi a}{2W}\right)^3\right]$$

where, P is applied load, a is crack length, B=1.2 mm, W=45 mm. Tensile tests were carried out with hydraulic fatigue testing machine under load control mode. Crack length and crack mouth opening displacement (CMOD) were measured with digital image analyses.

3. Results

Figure 2 shows the relationship between applied load and CMOD. Both stable and unstable crack growth were observed. Figure 3 shows the fracture resistance curve. Ductile unstable crack growth started at $K_{\mathrm{I}} = 7.2\ \mathrm{MPa}\sqrt{\mathrm{m}}$, and unstable brittle crack growth started at $K_{\mathrm{I}} = 8.6\ \mathrm{MPa}\sqrt{\mathrm{m}}$.

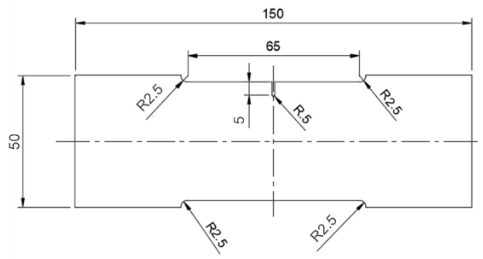

Fig.1 Single edge notched tensile specimen

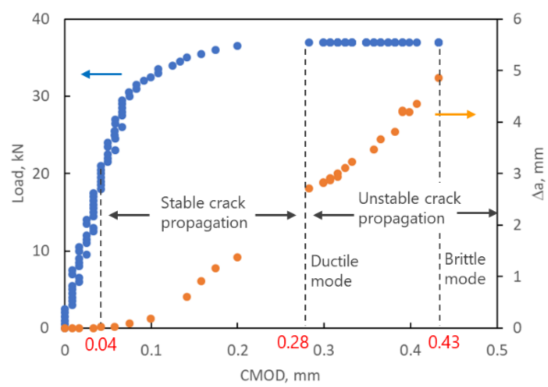

Fig.2 Applied Load and crack length

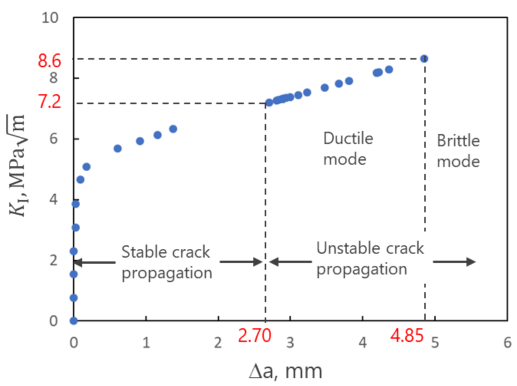

Fig.3 Fracture resistance curve

References

[1] R. Nishi et al., Study on Ductile Crack Propagation Prediction for Advanced High Strength Steels (1st report), 2018 JSAE Congress (Autumn), Nagoya, Japan, (2018).