§1. Development of the Fracture Toughness Test Method by Round Bar with Circumferential Notch

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1. Introduction

Fracture toughness is one of the most important mechanical properties among various properties of structural materials for machinery. Test methods of plane strain fracture toughness K_{IC} and elastic-plastic fracture toughness J_{IC} are standardized in ASTM[1]. However the methods are time-consuming and expensive. On the other hand, a convenient new test method, named J evaluation on tensile test (JETT), has been proposed to evaluate the fracture toughness of the tough materials[2-3]. The procedure of JETT developed in this two year joint research was shown.

2. The procedure of JETT

Searching for the size of JETT specimen with the same strain constraint around tip area as that of CT specimen by FEM calculations

In this research, for example, JETT625-6 indicates the ratio of notch and radius a/R=0.625 and radius R=6. Fig.1 shows the representative value concerning with maximum stress around tip area of each specimen with increasing J. To obtain Fig.1, the relationship between stress and strain of the material needs to be measured beforehand. The ordinate on the right shows maximum stress normalized by 0.2 % proof stress and that on the left shows such the normalized stress minus 3.5. In general, the normalized stress of plane strain CT specimen is independent of J and calculated on almost constant 3.5 of this material (Manganese steel quenched from 840 ℃ in a oil). Therefore the value zero of the ordinate on the left shows the same strain constant as the crack tip of CT specimen. The value of the ordinate on the left is called Q-factor. Since Q-factor of JETT625-8 and 625-6 within 40～190KJ/m^2 of J are almost zero, these specimens are candidates as an alternative specimen of CT. However the strain constrains around tip area of JETT625 series specimens below J=40kJ/m^2 are lower than that of CT. Therefore if an obtained experimental critical J of JETT625 series specimen is below 40KJ/ m^2, the value is invalid. On the other hand, the strain constraint at tip area of JETT750 series found to be too high.

Experiments of candidate specimens

In a procedure to evaluate a fracture toughness, the specimens other than candidate ones (in this material: JETT625-6, 625-8) don't need to be prepared for the experiments. However the other specimens were also tested for comparison in this research and the results are shown in Fig.2. Since obtained critical J values depend much on the R and a/R, the guideline to select equivalent one to the CT specimen is indispensable. The specimens with R=2mm or a/R<0.5 are excluded in Fig.2 because of too high or too low constraint around tip area, respectively. These tendencies of strain constraint were obtained by the experiments of last year.

Verify the predict critical J

252 ～ 302kJ/m^2 of JETT625-6 and 625-8 is predicted critical J values equivalent to the CT specimen. The values have to be verified by fracture mode observed by SEM fractography. Acoustic emission for detecting threshold load or displacement of the initial crack propagation is also useful to verify the estimation of critical J value. Both JETT625-6 and 625-8 are verified in these points. On the other hand, actual critical J value obtained by CT specimen was 275 kJ/m^2. It was within the predict value by JETT.

References

1) ASTM E1820-99a.: Annual book of ASTM standards (1999) 1000
2) Nishimura A. et al. : Adv. Cry. Eng. 44 (1998) 145
3) Nishimura A. et al. : Adv. Cry. Eng. 46 (2000) 33

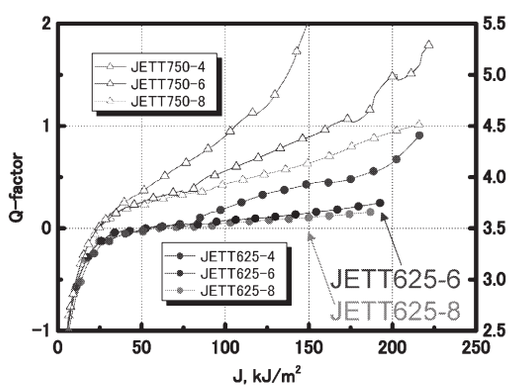

Fig.1 Q-factor of JETT

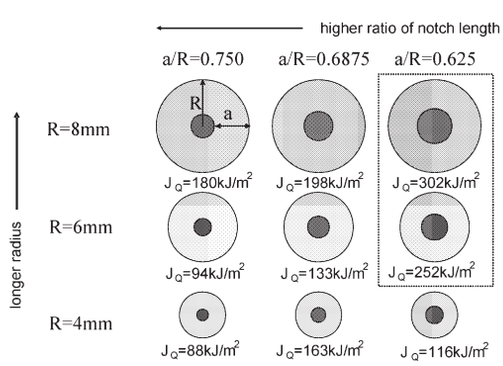

Fig.2 Experimental results