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

Kasaba, K., Katagiri, K., Shoji, Y. (Iwate Univ.)

1. Introduction

Fracture toughness is one of the most important mechanical properties among various properties of structural materials for machinery. Test methods of plain 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. And furthermore, laboratories being capable of conducting the experiments are limited due to the required experimental equipments. 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]. A JETT specimen, round bars with circumferential notch, is easier to be machined than a standardized specimen. Smaller specimen size is another advantage of JETT.

In this research, fracture toughness tests of the JETT specimens with various notch lengths and radiuses and those of standardized CT specimens for comparison were conducted. The purpose of the research is to get the knowledge about the development of that new fracture toughness test method from the experiments.

2. Experimental Procedure

For the development of the convenient test method by avoiding the many efforts of introducing axisymmetric fatigue crack, the possibility of the test using EDM (electro-discharge machining) notch has been tried[2-3]. Fig.1 shows the dimensions of the specimen. All the specimens were machined from a Manganese steel plate quenched from 840 ℃ in a oil. Its yield stress, ultimate tensile stress and reduction of area are 313 MPa, 546 MPa and 66 % respectively.

3. Results and Discussion

J=225 KJ/m^2 was obtained by the standardized J test method. On the other hand, various J values were obtained by JETT depending on the notch length a and radius R like shown in Fig.2. The J values of the specimen with a/R=0.75, R=4mm were the nearest value to that of standardized specimen. However the specimens with both R=2mm and R=4mm showed the fracture surface of the cup and corn type. Therefore the test results were not effective for the fracture toughness tests. On the other hand, the specimen with a/R=0.75 , R=8mm showed fracture surface of general toughness tests, fractured from notch root. Q-factor, one of the strain constraint parameters[4], of the specimen with a/R=0.75, R=8mm (not shown here) was also the same value with the standardized test. The best estimation for J value of the round bar with circumferential notch has been thought to be the Rice's approximate equation[5]. However the effectiveness of Rice's equation is limited in specific range of a/R and that after large amount of the plastic deformation and especially after necking was not known yet. J value of the specimen with a/R=0.75, R=8mm estimated by numerical line integral in FEM was J=190KJ/m^2, 15% less than the value obtained by the standardized CT specimen 225 KJ/m^2. Although there are some problems to be solved about new test method yet, the method has a possibility to be used to obtain fracture toughness of the structural material conveniently and at low cost.

References
1) ASTM E1820-99a.: Annual book of ASTM standards (1999) 1000
2) Nishimura A. et al. : Adv. Cryogenic Engng 44 (1998) 145
3) Nishimura A. et al. : Adv. Cryogenic Engng 46 (2000) 33
4) Shih C F. et al. : ASTM STP 1171 (1993) 2
5) Rice JR, Paris PC: ASTM Special Technical Publications 536(1973) 231

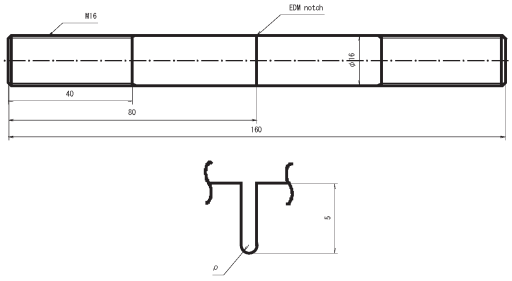

Fig.1 JETT Specimen.

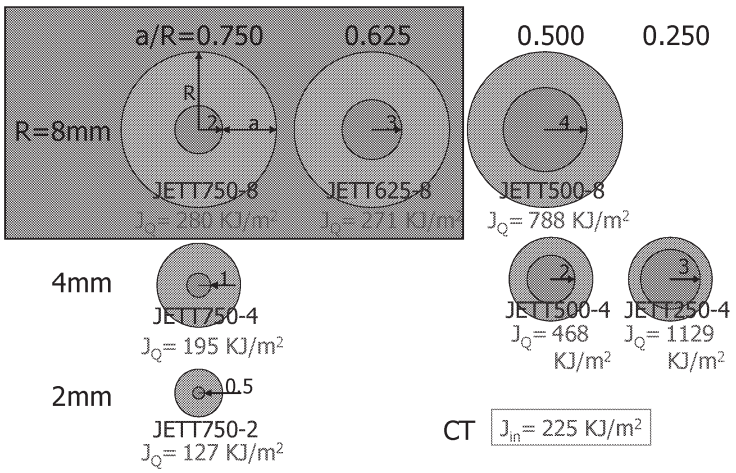

Fig.2 Experimental results