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To investigate mechanical properties, such as fracture toughness, of structural materials at cryogenic temperature, a crack length must be evaluated precisely. Generally, a mechanical test is carried out in the double wall cryostat and it is not easy to measure the crack length directly using an optical system. Therefore, unloading elastic compliance method is traditionally adopted and the evaluated crack length has been used when fracture toughness is obtained in experiments. However, when the smaller size specimen, such as 1/4 inch compact tension specimen (1/4 CT), is employed, the absolute crack length must have a certain precision, like less than 1/100 mm, to keep a significant figure.

In this study, the scatter of the crack length measurement with the unloading elastic compliance method was investigated. The specimen targeted was a 1/2 CT specimen. To perform the fatigue test off small size specimen precisely, a small capacity fatigue testing machine was installed. The maximum load for fatigue is +/- 5 kN and it has a servo-control system. The apparatus of the testing machine is shown in Fig.1. It is compact one and has an actuator at upper position of the cross head.

The specimen was a 1/2 CT specimen and prepared from a SUS304 stainless steel plate. An initial notch with 0.1 mm width was induced by electro-discharge machining. The both surfaces of the specimen were polished and the crack length was measure by a microscope of which magnification was 25 times, i.e. minimum scale was 0.05 mm. The specimen was fatigued under the load condition of 5 kN of maximum load and 0.2 kN of maximum load. The frequency was 5-6 Hz and down to 0.2 Hz when the measurement was done. Digital data sampling was carried out at 20 Hz with Digital Scope, DL708.

The compliance was measured by four ways. The first was determined by full hysteresis curve between 0.2 kN and 5 kN. The second was obtained from full hysteresis curve between 3 kN and 5 kN. In these cases, the compliance was measured making a linear regression line using full hysteresis curves. The third one was done making a regression line from 5 kN to 3 kN unloading process and the fourth was evaluated from the line from 5 kN to 4 kN as shown in Fig.2.

The evaluated results from these four methods are shown in Fig.3. At initial crack length, all results agree well. However, as crack growing, the difference becomes larger and there is no tendency to saturate to a certain value. As far as the data obtained, the fourth method gives a stable results and smallest scatter.

From these results, it would be concluded that the line immediately after the unloading starts is very important and it makes a small scatter, high precision data.

Fig. 1 Test apparatus for servo-controlled fatigue testing machine (maximum for fatigue: +/- 5 kN).

Fig. 2 Determination of unloading elastic compliance.

Fig. 3 Change in poloidal direction strain measured.