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Moving finite element analyses for dynamic nonlinear fracture of voided materials

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ABSTRACT

Since ductile fractures are often occurred in overloading accidents, clarification of ductile fracture mechanism is one of important problems in fracture mechanics. However, various complex behaviours are observed in dynamic nonlinear fracture. Large scale yielding, slant crack surfaces, dimple formation on crack surfaces and etc. prevent establishment of general nonlinear fracture mechanics. In this study, the moving finite element method, in which the Gurson void model is introduced [1], is used to simulate dynamic nonlinear fracture with dimple formation.

The Gurson void model [2] was re-evaluated by Tvergaard [3][4]. Here, effects of void new-creation and void growth are formulated based on the flow theory. For quasi-static nonlinear fracture in various types of specimen, Kikuchi and co-workers demonstrated numerical fracture path prediction simulations using this void model [5][6]. In their studies, it is shown that qualitative tendency for roughness of ductile fracture surfaces can be simulated by the introduction of the Gurson void model. In our previous study [1], the Gurson void model was introduced into the moving finite element method, which proposed by Nishioka and co-workers [7].

Figure 1 shows one of numerical specimen to simulate dynamic nonlinear fracture. Some analytical conditions are also shown in Fig.1. Because fracture is caused under higher deformation rates, elasto visco-plastic constitutive relationship is applied to

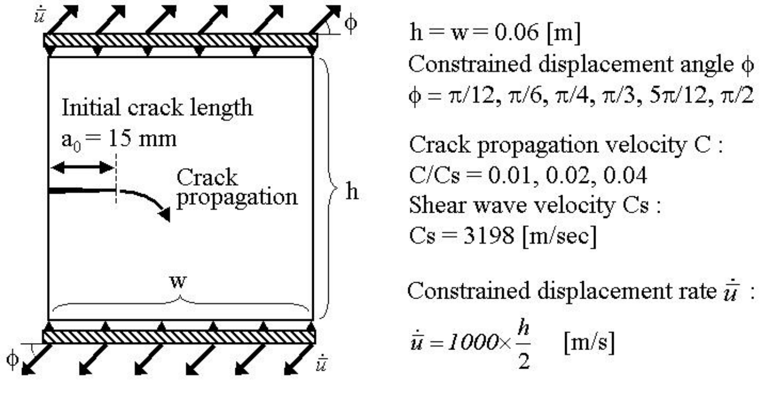

Figure 1 Numerical Model

express dynamic nonlinear deformation of material. In these simulations, some fracture path criteria are used to predict fracture path. In order to evaluate near-field condition, the T* integral [8] is calculated by path integration around current crack tip.

Void volume fraction distributions and predicted fracture paths for some constrained displacement angles are shown in Fig. 2. In these cases, the each fracture path is predicted by the maximum hoop stress criterion. Direction of the fracture path is depends on the constrained displacement angle. Distinct void growth occurs around crack propagation zone. It can be seen that void growth are intensified by high-speed crack propagation. Rapidly change of stress intensity on propagating crack tip vicinity raises higher visco-plastic strain rates and higher void growth.

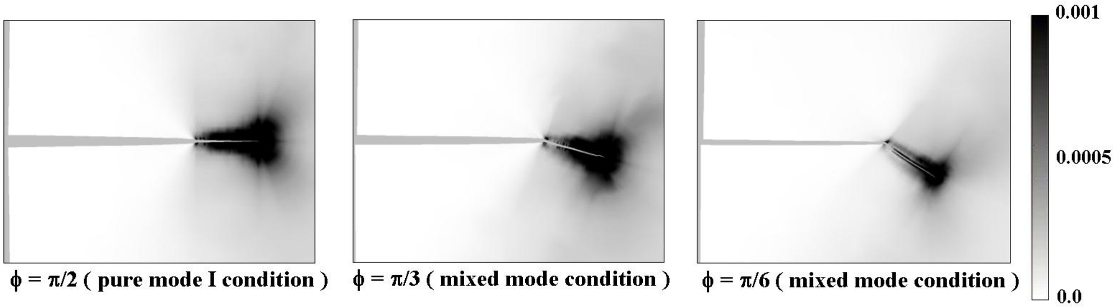

Figure 2 Void Distributions and Fracture Paths for Various Displacement Angles

On the other hand, at stationary crack stage, void growth area is restricted into crack tip vicinity. The T* integral is used as fracture criterion and it has far field path independence for voided materials. Other results will be explained in presentation. This study is supported by the Grant-in-Aid for Scientific Research from the Ministry of Education in Japan (No.19760070).

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