International Journal of Fracture **71**: R77–R78, 1995.

SUGGESTION OF A NEW CRITERION OF DYNAMIC FRACTURE INITIATION

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Dynamic fracture is a time-dependent phenomenon, it is generally agreed that brittle dynamic fracture requires the dynamic stress intensity factor to exceed the dynamic fracture toughness for a certain minimum time [1-3]. The experimental and theoretical study of the dynamic initiation of 4340 VAR steel by plate impact tests with the same duration of 1μs showed that the dynamic initiation process is dependent on the meso characteristic dimension of the material, namely, the interparticle spacing [4]. A sharp spike with a duration of less than 80 nanoseconds of the normal velocity at the rear surface of the specimen was observed by Prakash, Freund and Clifton [4] and this phenomenon was related to the onset of the crack growth. They modeled the crack initiation as the sudden formation of a very small hole at the crack tip, the radius of the hole, ϵ, agrees reasonably well with the interparticle spacing. This admits the possibility of dynamic crack-tip stress fields with crack-tip singularities stronger ($\sim r^{-3/2}$) than the inverse square root singular fields of fracture mechanics.

Tuler and Butcher [5] suggested a famous criterion for dynamic fracture

$$\int (\sigma - \sigma_0)^{\lambda} dt = K \tag{1}$$

where σ_0 might be assigned the value of the dynamic yield point or the static true stress for fracture. λ and K are constants. Obviously, $(\sigma-\sigma_0)$ is the overstress. In accordance with the 'least action criterion' proposed by Steverding and Lehnigk [6,7] for dynamic fracture and for convenience, here $\lambda=2$ is chosen.

By dimensional analysis, a new dynamic fracture criterion which is dimensionally equivalent to (1) is suggested as the following

$$\int_{t_0}^{t_1} \frac{(K - K_{Id})^2}{\epsilon} dt = C \tag{2}$$

where $\dot{K}_{Id}(\dot{K}_I,T)$ is the dynamic fracture toughness which is a function with respect to both loading rate $\dot{K}_I$ and temperature T, and $(K-K_{Id})$ is termed as the overstress

intensity factor. Similar to [4], ϵ is a meso characteristic dimension which can be taken as the interparticle spacing. C is a material constant, and t_0 is the time that $K=K_{Id}$.

For other values of λ, the corresponding criterion is expressed by

$$\int_{t_0}^{t_1} \frac{(K-K_{Id})^{\lambda}}{\epsilon^{\lambda/2}} dt = C$$

Acknowledgement: The support from the National Natural Science Foundation of China is acknowledged.

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5 May 1995