DYNAMIC CRACK INITIATION,
SOME EXPERIMENTAL METHODS
AND MODELLING

J.R. Klepaczko
University of Metz, Metz, France

ABSTRACT

The main purpose of this part of the book is to review new experimental methods which are useful and effective in determination of resistance to fracture under fast and impact conditions of loading. In recent decade a substantial progress has been made in this domain.

The first part concentrates on loading rate effects in fracture initiation and its theoretical basis. In general, the small scale yielding is considered, however, some cases of the large scale yielding are also discussed.

The loading rate spectrum is thoroughly analyzed. Experimental techniques and some results obtained within the low and medium loading rate are both considered. Over the region of higher loading rates application of elastic waves for testing fracture resistance is discussed. An emphasis is placed on application of Split Hopkinson Bar (SHB) to fracture dynamics (Modes I and III are discussed).

In the final part attention is being given to experimental results in crack initiation over a wide range of loading rates and temperatures. A modelling of the loading rate spectra is attempted. A generalized model for quasi-static, fast and impact loading of a stationary crack has been developed and discussed.

The experimental results are presented in such a way to be useful in practical applications. It is believed that a better understanding of the nature of the loading rate effects in metallic materials can be useful in preventing catastro-
phic failures under impact.

1. RATE EFFECTS IN FRACTURE, GENERALITIES

The definition of "Dynamic Fracture Mechanics" is very general, it applies not only to those problems where inertia forces are important but also to the problems where loading rates are fast enough to develop a time-dependent reaction of a crack. It follows that the class of problems associated with "Dynamic Fracture Mechanics" is very broad, from fast loading, impact, to shock waves interacting with cracks.

An isolated crack, oriented in the spatial coordinates \((x_1, x_2, x_3)\) or \((x,y,z)\) and with zeros at the crack tip, can be loaded in three basic modes:

Mode I - the opening mode,

a. plane strain ; \(\varepsilon_{33} = 0\) or \(\varepsilon_{zz} = 0\)

b. plane stress ; \(\sigma_{33} = 0\) or \(\sigma_{zz} = 0\)

Mode II - the sliding mode,

a. plane strain ; \(\varepsilon_{33} = 0\) or \(\varepsilon_{zz} = 0\)

b. plane stress ; \(\sigma_{33} = 0\) or \(\sigma_{zz} = 0\)

Mode III - the tearing mode, (no dilatation).

Fig. 1.1, Three basic loading modes: (a) Mode I-opening mode; (b) Mode II-sliding mode; Mode III-tearing mode; \(F_i\) are external forces which must be applied to obtain specific mode.