ALLOWING FOR INERTIAL EFFECTS IN IMPACT TESTS

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Determination of the fracture toughness (crack resistance) of materials under impact loading is of interest for the solution of both scientific and practical problems. As is known, this characteristic can be obtained experimentally from the results of tests of specimens of different configurations (usually specimens for three-point bending) with the use of different types of impact testing machines. Here, a load-time oscillogram is recorded and is used to find the critical value of force. However, until now there has been no standard method of analyzing the oscillograms, mainly due to the lack of a unanimous opinion on the method to be employed to allow for inertial effects manifest during testing.

Instructions on the fracture-toughness testing of materials under shock loads [1] recommend that the inertial force be determined from test data obtained on a specimen composed of two halves glued back together at the site of fracture, as was proposed in [2]. The resulting values of inertial force are then subtracted from the corresponding values of force on the oscillogram obtained in testing of the intact specimen. An analytical method of determining the inertial force was proposed in [3]. To determine fracture toughness, it is suggested that the value of this force also be subtracted from the inertial force of an experimentally obtained oscillogram.

An interesting method of determining fracture toughness in impact tests was proposed in [4]. It is based on the construction of so-called response functions, which can then be used to determine the breaking load.

It is recommended that the inertial force for Charpy-type specimens be found by multiplying the maximum force on the oscillogram by a factor whose value depends on the time to fracture [5].

As can be seen from this brief survey of existing methods of determining fracture toughness under impact loading, in nearly every case the inertial force is subtracted from the corresponding forces obtained on the oscillogram and thus is not considered in the determination of the breaking load. However, experience shows that inertial forces make a definite contribution to the specimen fracture process. It is a well-known fact that brittle objects break into pieces when dropped. What forces are responsible for their fracture? The cause of fracture is the action of the inertial forces of the object itself, these forces developing with the abrupt change in the object's velocity.

A different case is represented by tests in which the specimen is not supported. Here, the motion of the specimen is not restricted as it moves in the direction of impact. Naturally, the specimen will fail, given a sufficiently high impact velocity. The reason again for this failure is the inertial force which develops as the specimen is accelerated. The results of an experiment of this type were reported in [4]. In the first case, the specimen (object) is in motion until it impacts, while in the second case it is at rest. Here, the inertial forces which develop with acceleration or abrupt deceleration of the specimen have different directions and in both cases lead to fracture of the specimen.

It follows from the above that the inertial force which develops during the impact loading of a specimen has a significant effect on the process of its failure and, thus, needs to be accounted for in oscillogram analysis to increase the accuracy of fracture toughness determination.

Here, we propose a method which makes it possible to account for inertial effects in impact tests of prismatic specimens in three-point bending.

We will examine the case when a supported specimen is loaded by the striker of the impact testing machine during the test. As was shown in [4], the specimen loses contact with its supports at the initial moment of impact. Thus, we will ignore the force of interaction between the specimen and the supports when we determine the inertial force and its effect on the fracture process.

An inertial force $f_1(t)$ develops during acceleration of the specimen. This force is directed counter to the direction of specimen movement. We will make use of the distribution of inertial force over the specimen length (Fig. 1) obtained in [3] for the case in question:

$$f_1(t) = \frac{F_1(t)}{W} \left(0.306 - 1.574 \frac{x}{L_1}\right).$$ (1)

Then a bending moment from the inertial forces will act in the plane of the initial crack. This moment is equal to

$$M_1(t) = \int_{-L_1/4}^{L_1/4} f_1(t) \left(x + \frac{L_1}{4}\right) dx.$$ (2)