Some Problems of High-Speed Testing

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The success of the First Symposium on High Speed Testing has shown that a periodic review, even without pretense of being all-inclusive, satisfies a need felt by many workers in this field. This need springs from the fact that high speed testing poses many separate problems not encountered in ordinary testing. As a consequence, empirical procedures, often copying more or less successfully the actual process, have been developed, while the theoretical approach, which has to be rather different from conventional mechanics, stress analysis, or stress–rate of strain measurements, is at its very infancy. All the greater is the value of the present symposium and of its predecessor, and of a number of other papers in the recent literature, in providing material and useful analyses for a more concerted theoretical and experimental approach.

The reasons for the complexities and difficulties are much more obvious than the methods of dealing with them. There are, firstly, the inertial forces which modify the actually applied speeds and add to the stresses between differentially accelerated parts of the test specimen. The tensile and compressive elastic waves set up by an impact pulse have received considerable theoretical attention, but their superposition on a rapidly deforming specimen is yet little understood. Thirdly, the overriding part in failure played by flaws will be greatly changed by high speeds because the geometry of a fault may become more important than its size and, with the ability of the materials to flow and relax in the stress zone around the apex of a crack substantially reduced by speed, there ensues a general embrittlement. At the same time, though, the period till a flow grows into a failure will no longer be short compared with the time required to exceed the critical deformation, and larger strains than at low speeds may be observed which will lead to failures out of phase with the stress application, a form of delayed stress cracking.

Another interesting aspect of high-speed testing resides in the relation between crack propagation and crack branching. The advance of the crack apex will at first be slow and irregular as it meets with more resistant regions within the material. This gives peripheral stresses and weak spots a chance to open a system of secondary cracks which is tantamount to a mechanism of stress relief. Materials under conditions conducive to crack branching will shatter less readily and tend to cohere in the cracked state. Otherwise, the crack of right geometry requiring the least energy to propagate will win out and advance ahead of all others leading to large smooth fracture surfaces. Frequently one can observe in such cases the opening up of cracks ahead of the main front, indicating that the stresses preceding the front may be sufficient to overcome material cohesion at weaker spots in the path of the main split which thus follows some innate line of least resistance. It can be seen that a great deal of information can be read from a close inspection of fracture surfaces which indeed exhibit a record of the crack history.

It is equally revealing to inspect the dimensions of fractured specimen in the close vicinity of the fracture surface, since one will frequently find deformations and density changes indicative of flow anteceding the severing process. This is almost invariably true for the case of materials of so-called high impact resistance, which term should be understood as ability to consume energy by dissipative processes prior to those which create fresh surfaces.

These few remarks should be thought of as supplementing rather than introducing the papers of the present symposium. The latter will be found to present to you welcome and important contributions partly towards our understanding of mechanisms, partly with respect to the expanding area of instrumentation. I am looking forward to this, and future symposia, as becoming the nucleus for a comprehensive collection of publications on this so vital subject.