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Third Annual Symposium on High Speed Testing

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Introductions

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It is a pleasure to introduce these symposia which, in spite of their youth, have already become something of a tradition.

There has been a good deal of progress since the early days of impact testing, when the tester would get up on a stepladder, drop a steel ball onto a plate, watch it bounce, and look at the pieces afterward to determine what happened. This kind of testing is still done, but high speed testing has become a good deal more sophisticated.

Some of the most advanced apparatus in existence today is in the field of high speed testing because of the difficult problems involved in measuring extremely short time intervals and the necessity of obtaining reasonably detailed and exact information concerning what happened during the few microseconds or milliseconds of the test.

Two important measurements in most high speed tests are load and deformation. Since load cannot often be measured directly, it has to be determined by the deformation of a load-sensing device, such as a load bar. How can this be achieved in a few microseconds? Can it be achieved at all if a specimen breaks before the load pulse can get to the load-sensing device? How can a load or a strain be measured when the inertia of the measuring device is too great to allow it to follow the rapid increase of load or strain?

Resonance problems quickly arise. The point is soon reached where the speed of the test approaches the resonance frequency of the measuring apparatus and then reliable results cannot be obtained. Still more difficult is the case in which the speed of test is greater than the response time of the apparatus. Great ingenuity must be displayed in using such low-inertia high-response systems as beams of light or electron beams.

As in most fields of investigation, questions of semantics and definition arise. What is meant by high speed testing and impact testing? What is the threshold between high speed static testing and impact testing? To some people the difference lies in the velocity of propagation of pulses through the material. If the speed of test is less than the velocity of sound in the material it is still a "static" test even though conducted at high speed; if the speed of test is greater than the velocity of sound in the specimen it is an impact test. There are no universally accepted definitions of these terms and the investigator usually must define his terms when describing his work.

Another problem arises when the material being tested is not truly Hookean in its response, that is, it is rate-sensitive. Real materials seldom approach this ideal type of elastic response: depending upon the sensitivity of measurement, there is always some departure from it. Materials are temperature-sensitive as well. When materials display marked viscoelastic properties, their behavior at high rates of test is markedly different from that at ordinary rates; many of them approach a truly elastic response at very high rates—that is, the viscous component of their stress-strain behavior virtually disappears.

Some high speed tests are sensitive indicators of small changes in composition of the test material. Relaxation tests, for example, have been found to be good indicators of small changes in polymeric materials if the first few milliseconds of the test can be accurately recorded. Small changes in composition, changes in structure such as degree of crystallinity or extent of branching in the polymer, show up markedly in the early part of the relaxation test. This test can therefore be a useful tool in evaluating and determining the structure of such materials.

All sorts of special problems occur. One investigator may be testing filaments of gossamer fineness and his problem is to make almost inconceivably minute measurements in an almost inconceivably short time. Another investigator may be dropping ordnance items from a plane and must measure massive impact loads and deformations.

Both are high speed tests, but the measurement problems are different by many orders of magnitude.

Every conceivable method of applying loads and measuring the results is used. Blasts of gas, explosive charges, falling weights, flywheels, and many others are pressed into service, and the problems are daily increasing in complexity.

Recognizing the many ramifications involved and realizing the intensive developmental work under way, there can be little question concerning the value of symposia of this type. This is attested to by the steady increase in attendance; each year it has been greater and the printed collected papers are more and more widely disseminated.

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Although impact testing, as the simplest high speed test, is as old as the hammer, attempts at systematic and thorough study are very recent because of the difficulties in controlling and measuring all the independent variables. Advances in electronics have made it possible, and these symposia are witness to a substantial progress in our understanding of high speed phenomena and of the utilization of this progress in a wide variety of areas and usages. The strides made are due particularly to high speed recording, and it is significant that at this meeting every paper contains some tracings, or at least indications, of the stress-strain histories of the tests. Needless to say, such records form the basis of any attempts at a theory, or even classification, of the nature of a test.

In this respect, Dr. Spangler's comments on the borderline between impact and nonimpact are most helpful and well taken. In complete agreement with him, I should designate a stress-strain history as that of an impact when the stress (or strain) was never uniformly distributed through a specimen whether rupture had occurred or not. Since rupture may or may not coincide with the highest stress pulse or largest strain, a study allowing us to distinguish such cases would be most rewarding in that it would tell us to what extent imperfections had participated and whether the specimen was prone to delayed fracture. The same study should enable us to distinguish between the behavior at constant and at increasing speed.

Most important of all, in the stress-strain history we should be able to read how much plastic flow has occurred. Wolstenholme's paper offers a promising approach, and instrumentations at the National Bureau of Standards (Fiber Testing, Dr. Schiffer) and at General Electric (Plastics Division, Dr. Bueche) have also come a long way in providing experimental material. There is now good evidence that the so-called high impact materials such as PVC, high impact styrene, nylon, Delrin, Cycolac, and polycarbonates owe their performance to extensive flow prior to failure. In other words, at the limit of the capacity to store elastic energy either dissipative or rupture mechanisms must take over, whereby the former have the much greater ability to convert mechanical energy into heat and to lower dangerous levels of stored energy.

All the materials mentioned above have relatively low yield values but, owing to microinhomogeneity, show very high viscosities and, at that, not of the shear thinning type, when made to flow. Recent work by Bueche and Berry has shown convincingly that the fracture area of plastics becomes covered by material pulled out into fine films. It would be most rewarding to analyze the stress-strain histories for the distribution between flow and rupture energies and then to look for structural and physical features of the materials which may be responsible for the observed performances. Such analyses would provide the best guide to a development of better and more clear-cut test methods and of more satisfactorily performing materials.