

SYMPOSIUM ON DYNAMIC BEHAVIOR OF MATERIALS

INTRODUCTION

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The dynamic behavior of materials is an age-old problem. The first cave man probably became interested in this problem when he found that he could crush a skull quite readily with a blow from a club and yet the effects of this same club merely pressed against the skull were scarcely noticeable. However, having interest was far from understanding what happened to material under dynamic loading.

Until rather recently the only attempts to understand or measure the dynamic properties of materials was by the use of the impact test. It is interesting to note that Volume I of the ASTM *Proceedings* contains a paper on "The Present Knowledge Concerning Impact Testing" by W. K. Hatt and Edgar Marburg which was presented in 1899. A paper on "Tensile Impact Tests of Metals" by W. K. Hatt is included in Vol. IV of the *Proceedings*. These papers are evidence of the early interest of the Society in the dynamic properties of materials.

In 1935 H. C. Mann presented a paper on "The Relation Between Tension Static and Dynamic Tests." He followed this with a series of papers on tension impact testing. Another author who concentrated on the dynamic properties of materials was R. K. Bernhard whose first paper before the ASTM was "Dynamic Tests by Means of Induced Vibrations" which appears in the 1937 *Pro-*

ceedings. Since that time the studies of dynamic testing have become more numerous and the instrumentation more sophisticated.

From observation of the attempts to solve some of these problems it appears that the biggest difficulty is not in the impact loading of the material under test but the measurement of the stress-strain relationship that occurs during very rapid loading. The development of wire strain gages and other strain measuring devices of almost negligible mass and the development of electrical methods for measuring and recording strain and load have helped greatly in the development of newer test methods. One of the problems, however, is that one is inclined to assume that the properties of the measuring device are not affected by the speed of loading and that the device can be calibrated at some slower speed; at the same time, one hopes to measure the effect of speed of loading on a material that is tested in this device. There have been some ingenious methods for getting around this difficulty.

It has generally been found that it is easier to measure the energy absorbed during impact loading of a specimen than to measure the stress on the specimen. However, very often the design engineer would like to know how the material behaves under load at specific measured loading rates.

So far I have been talking about ultra high-speed testing. However, this prob-

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lem exists even at moderate speeds of testing. Most of us who work with metals have been inclined to feel rather sorry for our colleagues who are working with plastics since these materials are so strain-rate sensitive. However, experience has shown that some of the metals are sensitive to strain rates at the common laboratory speeds of testing. ASTM Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys initiated a program in 1950 to determine the effect of speed on the results of tension tests on stainless steel. A number of round-robin experiments were required before the committee was able to recommend a method for controlling the speed of test. This recommendation was finally made to the committee by the task group in 1958.

Failure due to fatigue is one important manifestation of the difference between dynamic and static properties of materials. This is another problem which puzzled engineers for many years, but it was only with the introduction of the railroad that the problem became sufficiently acute to require study. The first report on this subject was made by a British Royal Commission of railway engineers in 1850 who reported that failures of structures due to repeated stress could occur at loads far below the static strength of the material. About the same time (1847) Wöhler in Germany started his classic experiments on fatigue failure. His report was published in 1870. Since Wöhler, there have been many studies of the fatigue of materials, usually metals. This problem was the subject of

Marburg Lectures by Gough in 1933² and by Peterson in 1962.³ Much has been learned about fatigue failure in this 100 years of study. However, there are still many unanswered questions having to do with size and speed effects. Also the physical metallurgists are still not in complete accord as to the mechanism of fatigue failure.

Although the dynamic behavior of materials is a very old problem, this problem has been intensified with the introduction of modern aircraft and rockets. Not only do these devices impose stress at extremely high rates but also introduce combined environments that complicate the problem. These combined environments have always been present in such equipment as steam engines, gasoline motors, and marine equipment. However, we now have a new series of environments to contend with. Temperatures are much higher or lower depending on the application. All kinds of radioactive debris are encountered, and many devices must operate in a vacuum of an order which is extremely difficult to duplicate with laboratory equipment. For these reasons we need to intensify our attack on the problems inherent in the dynamic behavior of materials. It would appear from the program for this symposium that the attack is under way.

² Herbert John Gough, "Crystalline Structure in Relation to Failure of Metals—Especially by Fatigue," *Proceedings, Am. Soc. Testing Mats.*, Vol. 33, No. II, 1933, p. 3.

³ R. E. Peterson, "Fatigue of Metals in Engineering and Design," issued as separate pamphlet.