May 1975 B75-10073

NASA TECH BRIEF

Langley Research Center

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Automated Data Acquisition and Reduction System for Torsional Braid Analyzer

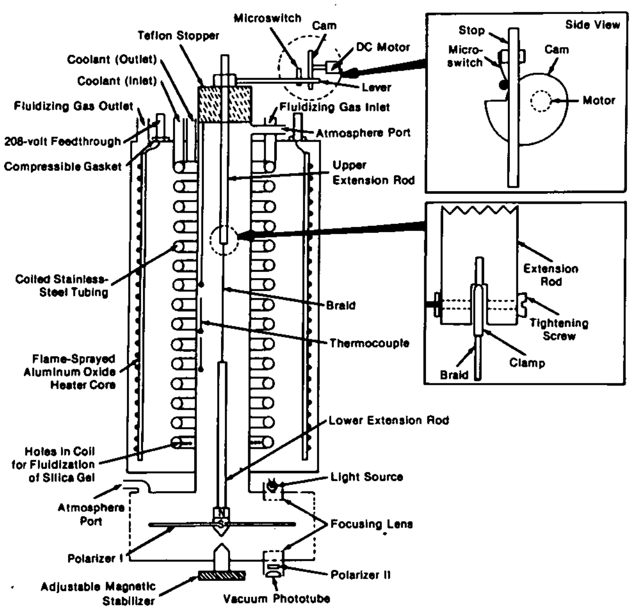

Figure 1. Torsional Braid Analysis (TBA) Apparatus

Torsional braid analysis (TBA) has become a well-developed and widely accepted technique for generating the dynamic thermomechanical spectra of polymeric materials over a wide temperature range. It is possible to measure the capacity of a polymeric material to store and dissipate mechanical energy of deformation using the technique. Such data enable the polymer chemist and engineer to establish relationships between chemical structure, submolecular motions, and processing and curing conditions.

The TBA method records the decaying torsional oscillations of a specimen, but it differs from a torsional pendulum apparatus in that it permits the investigation of materials that cannot support their own weight. The method is, therefore, suitable for studies of such chemical processes as resin curing and environmental degradation, and it allows the in-situ study of the effect of prehistory on thermomechanical behavior. It is particularly useful for investigating new polymer systems, since only a very small amount of polymer is required (<0.01 gram) and the principal criterion for making the test specimen is the simple solubility of the polymer in a removable solvent.

A specimen is prepared by the impregnation of a multifilament braid substrate with a solution of the material to be tested, followed by thermal removal of the solvent. The impregnated braid is enclosed in a chamber that can be cooled or heated in an inert environment (see Figure 1). The braid is set into free torsional oscillation by an initial torsional displacement. The subsequent displacement-time curve (a damped sinusoidal waveform), automatically recorded, provides data that, together with numerical and geometrical factors, are used to obtain the material parameters which are related directly to the storage and loss of energy of mechanical deformation.

The amount of data produced and handled during an experiment is enormous. A waveform is produced every few seconds, and each has to be individually analyzed during the data workup. An automated system, described below and shown in Figure 2, was developed to operate the TBA experiment automatically, i.e., to analyze each waveform and to provide low-scatter, high-resolution data in real time. The Automated Data Acquisition and Reduction System (ADAR) evaluates the damping coefficient and relative rigidity by storing four successive peaks of the waveform and the time period between two successive peaks. The damping coefficient and relative rigidity are then calculated and plotted against temperature or time in real time.

At the start of a sequence, a cam attached to a dc motor moves a spring-restrained lever which pulses the specimen. A wedge in the cam provides a positive starting and stopping point for the lever, thus ensuring that the initial amplitude of the specimen, when it is activated, is the same each time. The oscillations begin, and a calculator searches for the

(continued overleaf)

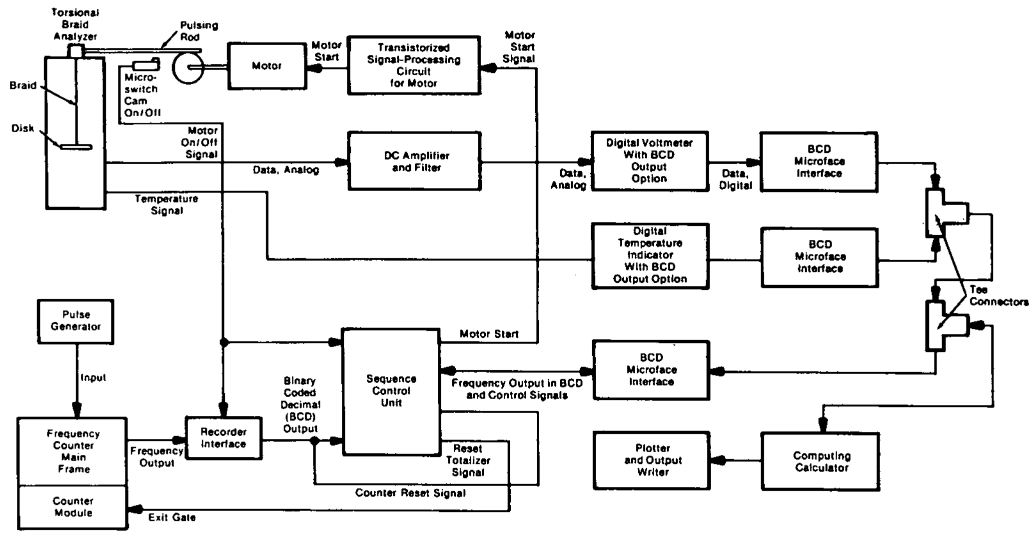

Figure 2. Automated Data Acquisition and Reduction System (ADAR) for Torsional Braid Analysis (TBA)

peaks in the damped sinusoid at a rate of 192 times per second, which is sufficiently fast to ensure accurate peak resolution.

When the calculator finds the first peak, it stores the data, initiates a counter, and starts counting the incoming pulses. The calculator then searches for the second peak (of the opposite polarity from the first peak), stores the second peak, and searches for the third peak (of the same polarity as the first peak). The calculator stores the third peak, accepts the counter data, and stores it at the time period of the damped sinusoid. A sequence control unit then resets the counter unit to its original state, as it does for each cycle. The calculator searches for and stores the fourth peak (of the opposite polarity from the first and third peaks).

The calculator acquires and stores the temperature information and proceeds to calculate the damping coefficient and the rigidity of the waveform. These are plotted versus temperature on a plotter and an output writer. The calculator then continues to search for peaks, always subtracting two adjacent peaks, until a preset minimum is reached, at which time the specimen is repulsed and the entire sequence is repeated.

Based on over 200 runs, this new TBA system has proved to be durable, with no observed degradation in performance. It has required less repair and less manpower for operation than conventional systems and has tripled the number of analyses per man-hour. It has minimized human error in the handling and calculation of data. Also, with real-time operation, a spectrum can be monitored as an experiment proceeds; hence, conditions and operational procedures can be altered or corrected, as required, during the experiment.

Note:

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Reference: B75-10073

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Wyle Laboratories, Inc.
under contract to
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(LAR-11578)

Categories: 04 (Materials)
02 (Electronics Systems)