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NASA TECH BRIEF

Ames Research Center

Monitor for Physical Property Changes in Solid Propellants

The problem:

The physical properties of solid propellants (and other polymeric materials) gradually change over long periods of time, especially at high temperatures. To assure proper performance of a propellant while it is in a rocket, it is necessary to check its physical properties periodically, but the main grain is not accessible for purposes of testing. Thus, at present, control blocks of the propellant which are cast at the same time with the main grain are stored in the same environment as the grain; periodically, the physical properties of the blocks are measured, and it is assumed that any detectable changes must also have occured in the propellant grain. It would be desirable to be able to enclose a sensitive sensor in the grain which could be periodically interrogated, thereby revealing the current status of the physical properties of the grain.

The solution:

Attach a mass to the propellant (or imbed a mass in the propellant); when the mass is driven into vibration by a suitable means, it will move with a phase lag which is directly proportional to the internal friction or loss coefficient. Also, the resonance frequency of the system is related to Young's modulus; the modulus or the internal friction can readily be monitored over a long period of time.

How it's done:

The specially-designed sensor which was developed during a program of study consists of a rigid cylindrical sheath firmly anchored at one end and terminating in a quasi-spherical mass at the other; inside the sheath, and concentric with its internal diameter, is a torsional element fastened to the spherical mass. The upper end of the torsional element is equipped with a disc which is set into an oscillatory motion about its axis by suitably disposed electromagnets driven from an alternating current source; pickup coils are used to telemeter the amplitude of the oscillation, which is determined by the physical dimensions of the sensor and by the damping effect of the medium in which the spherical mass is embedded.

Alternating current is supplied in a programmed scan mode to the electromagnets in the sensor at frequencies ranging from about 50 to 1000 Hz; plots of the alternating voltage generated by the pickup coils *vs* the drive frequency will show a peak at the resonance frequency of the combination comprised of the sensor and the propellant system in which it is embedded. Phase lags between the drive current to the electromagnets and the voltage developed by the pickup coils are determined in the usual manner by an oscilloscope.

The results of a test program which included a study of the performance of various designs of embeddable sensors have established that the torsional sensors have long-term stability, that is, their performance characteristics do not change with age. Other sensors which have been studied measure the push-rebound characteristics of propellants; although these sensors perform well, they monitor only the propellant on or near the surface and not the main bulk. Moreover, bonding of the push-rebound sensors to the propellant surface has not been satisfactory. The test program has also demonstrated a satisfactory correlation of sensor resonant frequency with the tensile moduli of propellants.

(continued overleaf)

Notes:

1. A typical sensor which has been found satisfactory for monitoring propellants is described in U.S. Patent 3,382,706.
2. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)
   Reference: NASA CR-114456, Development of a Remote Vibrating Sensor for Monitoring Physical Property Changes in Solid Propellant.

3. No other documentation is available. Specific questions, however, may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B73-10130

Patent status:

NASA has decided not to apply for a patent.

Source: Robert E. Black, Jr. of
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