mechanical properties of a solid propellant to a high degree can be readily removed on exposure to vacuum, and can also be reabsorbed upon re-exposure to atmosphere. I suggest that in addition to pre-exposure properties, the weight loss noted by the authors was substantially recovered upon re-exposure to the atmosphere. I also suggest that similar results could have been obtained had the specimens been tested in a desiccated environment.

References

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[3] Fishman, N., in "Space Environment Effects on Polymer Materials," Project ASD-4257, JPL Contract 950324, May 1965, Stanford Research Institute, pp. 37–50.

[4] Fishman, N., in "Polymers for Spacecraft Hardware: Materials Characterization," Project ASD-5046, JPL Contract 950745, Dec. 1966, Stanford Research Institute, pp. 51–73.

Reply by Authors to N. Fishman

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THE main purpose of our Note was to show that vacuum-induced changes in the engineering properties of certain elastomeric materials must be determined by measuring the properties in the vacuum environment (in situ). This approach is in contrast to two other approaches in common use: 1) measuring the engineering properties before and after exposure to the vacuum environment, and/or 2) measuring the vacuum weight loss and assuming that the magnitude of the weight loss is indicative of changes in engineering properties. Our results showed that neither of the latter two approaches is valid for the materials studied.

The complete results of our study on the composite solid propellant are presented in Ref. 1, which describes a phenomenological model for the behavior. The analysis[1] indicates that vacuum exposure removes interfacial moisture that results in the observed property changes. Thus, our results are in accord with Fishman's comments on moisture effects. Reference 1 also describes tests of samples in a desiccated environment (dry nitrogen) and the results show that, at a given storage time, the changes in mechanical properties for the samples stored in vacuum were substantially greater than for the samples stored in a desiccated environment.

The authors recommend that in situ engineering properties measurements be used to evaluate spacecraft materials rather than weight loss or other peripheral measurements.

Reference

[1] Greenwood, L. R., "The Effect of Vacuum on the Mechanical Properties of a Solid Rocket Propellant During Space Storage," thesis, May 1967, Virginia Polytechnic Institute, Blacksburg, Va.; University Microfilms, Order 68-2047.

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Comments on "Wobble-Spin Technique for Spacecraft Inversion and Earth Photography"

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ALTHOUGH the results of a recent paper[1] by Beachley and Uicker are correct for the assumptions made, it should be emphasized that the concept cannot be reasonably implemented for the stated application. The paper clearly states that the wobble-spin technique is a workable concept "if certain prescribed spacecraft moment-of-inertia relationships are maintained" but then fails to consider the devastating effect of a small deviation from those mass property constraints. It is instructive, in terms of feasibility, to consider the performance of the proposed system in the presence of a small deviation from the idealized mass properties. Their Eqs. (A11–A13) are used as published;

$$I_{11}\dot{\omega}_1 = -J_0\dot{\Omega} + (I_{22} - I_{33})\omega_2\omega_3 \tag{A11}$$

$$I_{22}\dot{\omega}_2 = -J_0\Omega\omega_3 - (I_{11} - I_{33})\omega_1\omega_3 \tag{A12}$$

$$I_{33}\dot{\omega}_3 = J_0\Omega\omega_2 + (I_{11} - I_{22})\omega_1\omega_2 \tag{A13}$$

Instead of rewriting the equations at once with the oversimplifying constraint $I_{22} = I_{33}$ (as in Ref. 1), it is better to solve the general equations for small deviations from the initial conditions. Consider the wheel accelerating period to be very short, after which the wheel runs at constant speed Ω specified by their Eq. (A23). The unsymmetrical spinning spacecraft may be conveniently analyzed by introducing a factor k as in Ref. 2, where

$$k^2 = I_{22}(I_{22} - I_{33})/I_{11}(I_{11} - I_{33})$$

and

$$\omega = \omega_1 + ik\omega_2$$

Then, considering $|\omega| \ll 1$ and $\omega_1 t \ll 1$, the e_3 axis remains near the angular momentum vector and Eqs. (A11–A13) reduce to

$$\begin{aligned} \dot{\omega}_1 - \Omega_1\omega_2 &= -J_0\dot{\Omega}/I_{11} \\ \dot{\omega}_2 + \Omega_2\omega_1 &= -J_0\Omega p/I_{22} \end{aligned} \tag{1}$$

where

$$\Omega_1 = p\left(\frac{I_{22} - I_{33}}{I_{11}}\right) \quad \Omega_2 = p\left(\frac{I_{11} - I_{33}}{I_{22}}\right)$$

$$p = \omega_3 \approx \text{const}$$

Equations (1) become

$$\dot{\omega} + i\Omega_n\omega = -\dot{h}/I_{11} - ikhp/I_{22} \tag{2}$$

where $\Omega_n = (\Omega_1\Omega_2)^{1/2}$, and $h = J_0\Omega$ = angular momentum of reaction wheel. The solution of Eq. (2) for $t < t_1$ (where t_1 = wheel acceleration period) is

$$\omega = \omega(0)e^{-i\Omega_n t} + i(1 - e^{-i\Omega_n t})(1/I_{11}\Omega_n - kp/I_{22}\Omega_n^2)\dot{h} - (kp\dot{h}/I_{22}\Omega_n)t \tag{3}$$

The nutation frequency Ω_n is near zero, so that $\Omega_n t_1 \ll 1$ (where t_1 is the wheel accelerating period; $t_1 \ll 1$), and with $\omega(0) = 0$ the spacecraft motion at the end of the wheel accelerating period is

$$\omega(t_1) \approx -\dot{h}t_1/I_{11} = -J_0\Omega/I_{11} \tag{4}$$

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