NOTES

Treatment of Propellant Mechanical Property Data by Reaction Rate Analysis

Several investigators[1-3] have applied reaction rate analysis in an attempt to correlate mechanical data. A relationship of the form

$$\log t_f = C - \log T + (\Delta F\dagger/2.3RT) + bS/T \tag{1}$$

has been used. In eq. (1), t_f is the lifetime (or time to failure) of a material under mechanical restraint, T is absolute temperature, $\Delta F\dagger/2.3RT$ is the activation energy term, S is the macroscopic stress, and b and C are constants.

We have applied such a treatment to the data of McAbee and Chmura.[4] These investigators studied tensile properties of cast and extruded solid rocket propellants over the temperature range −60 to 80°C. at two rates of loading, one at very high and the other at 0.1 in./in./min.

Equation (1) may be rewritten as

$$(\log t_f T - bS/T) = C + (\Delta F\dagger/2.3RT) \tag{2}$$

According to eq. (2), a plot of $(\log t_f T - bS/T)$ versus $1/T$ should be linear. Trial values of b were selected and plotted according to this equation. Figure 1 illustrates such a plot for the high-rate data on one of the propellants. For the high-rate data the lines appeared to be satisfactorily linear only at or near $b = 0$. Figure 2 shows this linearity for all four propellants.

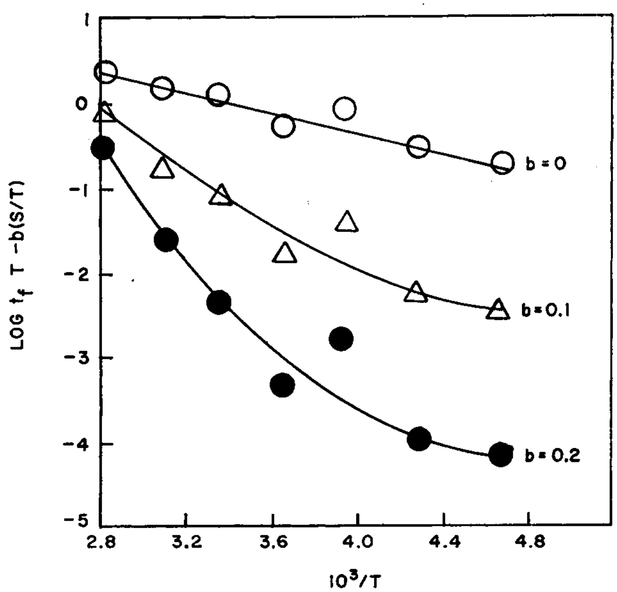

Fig. 1. Plot of $\log t_f T - b(S/T)$ vs. $1/T$ for OGK propellant at the indicated values of b.

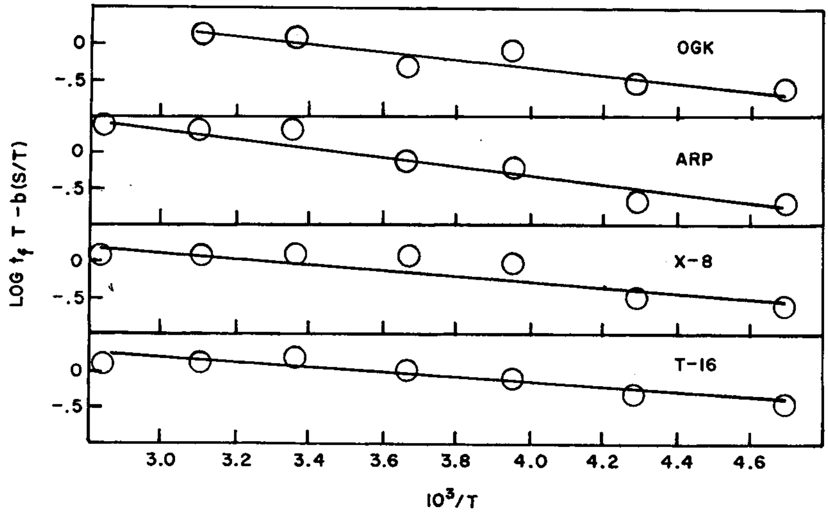

Fig. 2. Plots of log t_fT vs. $1/T$ for the propellants indicated at high rates of loading.

At the lower rates of loading for these same propellant materials the linearity again is satisfactory for a selected value of b. However, in this case b is not zero. Also in each case there appears to be a transition temperature which gives a discontinuity in the log $t_fT - b(S/T)$ versus $1/T$ lines. On either side of this temperature, straight lines are obtained at the same value of b (Figs. 3 and 4), but the slopes are different. It is interesting that the values of b giving linearity are the same for the two cast materials (OGK and ARP). For the extruded materials (T-16 and X-8) b is also constant but differs from the value for the cast specimens. Based on these results, it appears that the method of manufacture exerts more influence on this parameter than does the material composition.

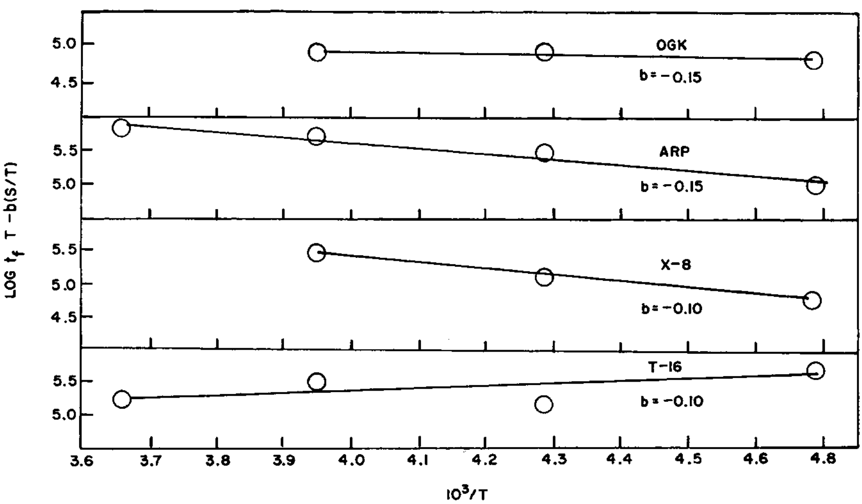

Fig. 3. Plots of log $t_fT - b(S/T)$ vs. $1/T$ for the propellants indicated at lower rates of loading.

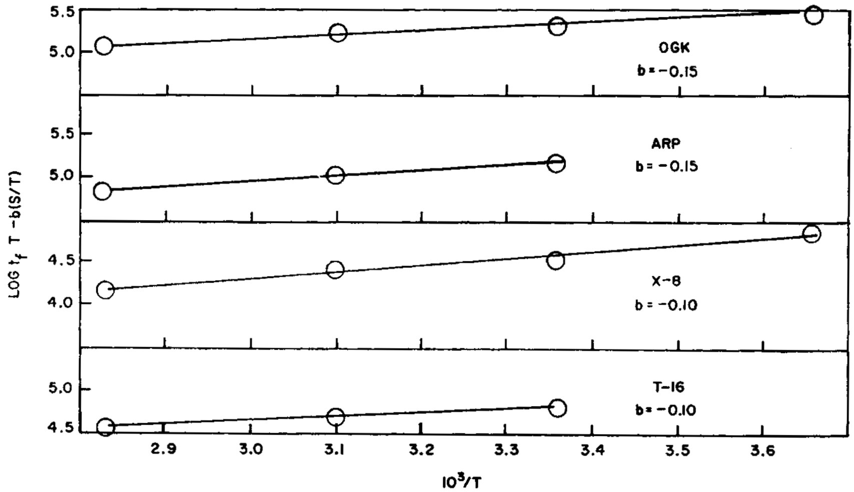

Fig. 4. Plots of log $t_fT - b(S/T)$ vs. $1/T$ for the propellants indicated at lower rates of loading.

The foregoing indicates that reaction rate analysis can be applied to such propellant mechanical property data and that it should be possible to make some predictions as to strength–temperature behavior from limited test data.

References

1. B. D. Coleman and A. G. Knox, *Textile Res. J.*, **27**, 393 (1957).
2. W. E. Wolstenholme and C. F. Stark, Report No. 1, Contract DA-18-035-AMC-139(A), Oct. 10, 1964.
3. E. McAbee and D. W. Levi, *J. Appl. Polymer Sci.*, in press.
4. E. McAbee and M. Chmura, *J. Appl. Polymer Sci.*, **8**, 3 (1964).

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