

Also

$$E_n = E_p(X_n) + \frac{3R}{M} T_n \left[1 + \frac{1}{20} \frac{\theta_n^2}{T_n^2} \right]$$

from the equation of state (Sec. III.B). Hence E_n can be eliminated between the equations and the equation for T_n becomes

$$T_n^2 - \frac{M}{3R} \left[E_{n-1} + \frac{1}{2} V_o (P_n + P_{n-1}) (X_{n-1} - X_n) - E_p(X_n) \right] T_n + \frac{1}{20} \theta_n^2 = 0.$$

Now all (P_n, V_n, T_n) reverberation states can be calculated if u_p and T_o are given.

Using resistivity theory results (Sec. III.A.4), the resistivity change due to temperature rise is also calculated. Computations show that at 100 kbar the thermal resistivity change is 4% lower than for a single shock. The graph of shock isothermal resistivity versus pressure is not strongly affected by the correction, but the amount of resistivity change attributed to defects generated by the shock is about 20% higher on the MRC curve and 4.5% higher on the W3N curve after the multiple shock calculation for the data points.

2. Temperature Rise Due to Plastic Deformation

Plastic deformation is an irreversible process. The entropy rise increases the thermal energy, which influences the temperature rise due to the shock wave.

Although the shock transition is achieved by irreversible processes, initial and final thermodynamic states are considered to be equilibrium states on the equation of state surface of the shocked substance. If entropy production can be

expressed as a function of volume, then temperature can be found from an integration of

$$T dS = C_V dT + \frac{Y}{V} T dV \quad (8)$$

along an equilibrium path (the Hugoniot curve) between initial and final states.

According to the theory of irreversible thermodynamics, define a local entropy $S(X_0, X_1, \dots)$ with functional dependence on local extensive parameters X_0, X_1, \dots identical to its dependence in equilibrium thermodynamics (Callen, 1960).

Then

$$dS = \sum_K F_K dX_K$$

where the F_K are local intensive parameters (entropy representation) having the same functional dependence on local extensive parameters as intensive parameters in equilibrium thermodynamics do.

In the shock transition there is entropy production due to plastic deformation and due to the hydrodynamic shock process itself (viscous dissipation) $dS = dS_1 + dS_2$ where

$$dS_1 = \frac{V}{T} \sum_j s_j de_j^p = \frac{V}{T} \left(\frac{4}{3} \tau \right) \left(d\epsilon_x - \frac{d\tau}{\mu} \right)$$

as in Eq. (5) and (6). An expression for dS_2 can be found using the Rankine-Hugoniot relation

$$dE = \frac{1}{2} dP_x (V_1 - V) - \frac{1}{2} (P_x + P_x^1) dV$$

where V_1 and P_x^1 are values at the Hugoniot elastic limit.

Locally, for the hydrodynamic process

$$dS_2 = \frac{1}{T} dE + \frac{P_x}{T} dV$$