6. CONCLUDING REMARKS

In this paper we have increased the generality of the previously developed system of equations governing the kinematics of the propagation of one-dimensional strain waves of finite deformation in an elastic viscoplastic material to include the effects of heat generated by both adiabatic compression and plastic dissipation. This allows us to extend the range of validity of an earlier method which was developed for the purpose of computing in a simple manner the most important features of plane shock waves in polycrystalline metals. This earlier method neglected the effect of temperature rise through the shock wave. Since interest in the method arises from the use of plane wave experiments to study the high speed motion of dislocations in metals the neglect of the temperature rise caused by shock heating somewhat restricts the range of shock pressures and consequently of dislocation velocities to which it might be applied. Dislocation motion in metals is generally held to be governed by thermally-activated mechanisms which are sensitive to temperature.

To take thermal effects partially into account we at first conjectured that neglect of the temperature rise due to plastic work would allow a reasonable approximation to the total temperature rise and obviate the need to consider the history of the stress and strain implicit in the plastic work term. However, at pressures of the order of 100 kb, for example, the contribution of the plastic work is far from negligible. We have been able to show, as a consequence of the kinematic conditions of uniaxial plane strain together with the especially simple form of dynamical condition pertaining to the steady plane wave situation, that the temperature rise including the plastic work effect can be computed as a function of density without requiring the specification of the viscoplastic constitutive equation relating the plastic strain rate to strain, stress and temperature. This we feel to be an extremely important conclusion for it removes the need which frequently occurs in dynamic elastic problems of guessing a constitutive equation before using a result to establish what the correct, or most accurate, constitutive relation actually might be.

It should be noted that the approach to the derivation of the constitutive equations used here is an alternative to the approach used by others through extension of the hydrodynamic theory. This approach considers the stress in the hydrodynamic theory as an equilibrium stress and superposes a rate dependent stress. We prefer to approach the theory through the concept of elastic and inelastic strain rates since it allows us to incorporate directly plastic strain-rate constitutive equations suggested by modern theories of dislocation motion.

We have developed an integral equation for the temperature rise as a function of density and given a highly accurate approximate solution to it. Knowing the temperature in terms of density through the wave it is then straightforward to incorporate this into the method developed in (KG) and thus determine more accurate predictions of the influence of dislocation motion on the mechanical behaviour of the material.

Some examples are given and it is clear from the results shown in Fig. 7 that thermal effects can be expected to play a significant role in the establishment of shock profiles.

ACKNOWLEDGMENT

This work was supported in part by Air Force Contract F 33615–69–C–1027 with the University of Kentucky and by National Science Foundation Grant No. 10070 to the University of California. The numerical analysis was done using facilities at the University of Kentucky Computing Center.

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