THE ELASTO-PLASTIC RELEASE BEHAVIOUR OF MAGNESIUM AT 80 Kb

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ABSTRACT

A technique has been developed, based on the manganin wire transducer, which enables the stress-time profiles of shock and release waves produced in a block of magnesium by the impact of an explosively driven flying plate to be recorded. The profiles presented differ from those that would be predicted by hydrodynamic theory; in particular, the top of the release wave is traveling approximately 30% faster. A release stress-strain path is derived from the results and it is shown that this can be interpreted in terms of elasto-plasticity.

INTRODUCTION

There has been considerable discussion in the literature recently suggesting that the behaviour of solids under high shock stresses cannot be adequately described by hydrodynamic theory, and that the effects of yield strength are important [1]. Several experimenters have reported the initial parts of release waves behind intense shocks travelling faster than hydrodynamic theory would predict [2-5].

We have attempted to match the manganin wire transducer to a metal so that it can be used to record the stress-time profile of a plane wave inside the material, instead of observing a free surface. The advantage of this method is that, in principle, the interpretation of the results is simplified, and a complete mathematical analysis is possible, uncomplicated by lateral strain effects which have plagued much of the earlier work on plastic waves using rods and wires [6], or by the need to assume a particular theory of plasticity. Our preliminary results with magnesium show that stress-time profiles can be observed and that these can be used to calculate the stress-strain path of the release process.

TECHNIQUE

A transducer based on the linear pressure-resistance characteristic of manganin has already been used to measure stress as a function of time in electrical insulators [7]. To extend this technique to a metal it is necessary to insulate each manganin wire and its leads from the surrounding metal without invalidating the stress-time profiles obtained. This may be attempted by using an insulator whose shock impedance approximates to that of the metal used, and by making the insulating layer so thin that any significant reverberations in it are over in a time which is short compared with that being measured.

Figures 1 and 2 show the design used. The manganin wire, of 0.005-inch diameter coated with glass to 0.008-inch overall diameter, is cast in the middle of a 0.025-inch layer of epoxy resin, loaded with powdered lead borate glass of density 6.1 gm/cc. The copper support tubes are 0.050-inch diameter, surrounded by 0.250-inch diameter soda lime glass tubing, which is a fairly good shock impedance match to magnesium. The loading of the epoxy resin was chosen so that the proportional sum of the compressed volumes of the constituents was equal to the specific volume of magnesium at the pressure of the experiment. Glass and epoxy resin were used because in previous work they have been found to be adequate insulators when shocked. The effectiveness of the insulation was shown by the agreement obtained between the measured peak pressure and that predicted from the shock and flying plate impact velocities. In addition the accuracy with which the wire resistance returned to its initial value after the passage of the stress wave indicated that the insulation remained satisfactory and that good contact with the wire was probably maintained.