VISCO-PLASTIC MODEL WITH TIME RETARDATION FOR HIGH-VELOCITY IMPACT LOADING OF OFE COPPER SPECIMENS

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OFE copper (Oxygen Free Electrolytic copper) is extensively used in military engineering for the design of shape charge warheads. Use is made of its excellent deformation capabilities to initiate a metal jet for the target penetration moving with the speed of several kilometers per second. Gray and Follansbee (1988) conducted unique experiments with OFE copper specimens subject to such extreme loading conditions. Controversial results were obtained that could not be explained by any existing visco-plastic theory. The authors of this paper made an attempt at an explanation by introducing a specific visco-plastic model with time retardation. In the present work the model was cast to the format of the standard continuum mechanics equations.

Key words: *visco-plastic model, shock wave, time relaxation, adiabatic shear bands*

1. Introduction

Since the pioneering work of Campbell [1], who carried out shock experiments up to 11 m/s of impact velocity, it has been known that materials can withstand much higher short duration stresses than the yield stress without exercising pronounced plastic flow. In general, this phenomenon can either be understood as an increase of the dynamic yield stress caused by disclocation viscous damping or, as in the famous Perzyna overstress model [2], it can be attributed to the lack of time the permanent strain has to develop.

Regardless the correct physical explanation, much experimental evidence was gathered over the years, using chiefly the split Hopkinson pressure bar technique and the Taylor tests. A comprehensive updated review can be found in reference [3]. For various reasons, both experimental methods are somewhat limited to impact speeds not exceeding approximately 500 m/s. Even at that velocity, which can be reached in Taylor's test, it is extremely difficult to process experimental data when the stress state in a thick cylinder is considerably complicated. In contrast, much more favourable situation arises in the colliding plates test where, provided some countermeasures to suppress spallation are taken, the shock profile is quite simple and uniaxial.

Indeed, despite their expensiveness, such tests were conducted by Gray and Follansbee [4] who, in 1988, reached incredible 2 km/s impact speed corresponding to a dozen of GPa contact pressure. However, these experiments also discovered strange material response under extreme loading conditions that could hardly be explained by any standard visco-plastic

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