Determination of the Constitutive Relation Parameters of a Metallic Material by Measurement of Temperature Increment in Compressive Dynamic Tests

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Published online: 14 July 2009
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Erratum to: Experimental Mechanics
DOI: 10.1007/s11340-009-9223-z

Introduction

Thermal Increment and Plastic Deformation

For an elastic-plastic material in uniaxial stress condition and considering an additive partition of the strain, the equation of energy balance is

$$\lambda \nabla^2 T - \dot{T} = -\frac{\beta}{\rho \cdot C_p} \sigma : \dot{\varepsilon}^p + \frac{\alpha}{\rho \cdot C_p} \frac{E}{(1-2\nu)} T \operatorname{tr}(\dot{\varepsilon}^e) \quad (1)$$

where T is the absolute temperature, σ the stress tensor, $\dot{\varepsilon}^e$ the elastic strain rate tensor, $\dot{\varepsilon}^p$ the plastic strain rate tensor and $\operatorname{tr}(\dot{\varepsilon}^e)$ is the trace of elastic strain rate tensor; λ is the thermal diffusivity of material, ρ the mass density, C_p the

specific heat, α the coefficient of dilatation, ν the Poisson's ratio and E the Young modulus; β is the Quinney-Taylor parameter representing the proportion of plastic deformation energy that becomes generated heat.

In Eq. (1) (equation of energy balance or equation of heat propagation),

$$\lambda \nabla^2 T$$

is the heat lost by conductivity,

$$\dot{T}$$

is the temporal temperature variation per unit of volume,

$$\frac{\alpha}{\rho \cdot C_p} \frac{E}{(1-2\nu)} T \operatorname{tr}(\dot{\varepsilon}^e)$$

is the temperature variation associated with the elastic strain,

$$\frac{\beta}{\rho \cdot C_p} \sigma : \dot{\varepsilon}^p$$

is the temperature variation associated with the plastic strain.

The online version of the original article can be found at <http://dx.doi.org/10.1007/s11340-009-9223-z>.

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