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Contribution towards the characterization and modelling of micro-spalling in shock-melted tin.

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When a pressure wave produced by high-velocity impact, high-explosive detonation or laser irradiation reaches the free surface of most metals, strong tensile stresses are generated and can lead to the well-known spallation fracture by nucleation, growth and coalescence of micro-voids (ductile behaviour) or micro-cracks (brittle behaviour). In the case of intense shock-wave loading the metal is melted then, because of the associated loss of strength, a fragmentation process takes place in the liquid state. This phenomenon is commonly referred as micro-spalling [Andriot et al., APS Conf. Proc., 1983] but, contrary to spallation and fragmentation of solids, both experimental data and theoretical works are still sparse.

Experimental investigation has included plate impacts and laser-driven shocks on tin associated with time-resolved velocity measurement and sample / ejecta recovery device. It provides fundamental data concerning the micro-spalling process.

Theoretical and numerical analysis of existing fragmentation models based on global energetic approach [Grady, J. Mech. Phys. Solids 36(3), 1988] leads to the formulation of a fragmentation criterion appropriate for micro-spalling that is implemented in a hydrocode. Computations provide a first description of the droplets cloud in terms of size and velocity distributions, as well as information about the state of the liquid and its evolution. In parallel, a second modelling approach aims at identifying the physical mechanisms responsible for fragmentation during the micro-spalling process. Cavitation, observed experimentally [Stebnovskii, J. Appl. Mech. Tech. Phys. 39(5), 1998], is described by means of a hollow sphere model that allows defining the conditions for which the growth of micro-voids can lead to fragmentation in liquid metals. Quantitative results strengthen some predictions of the former fragmentation model based on energetic approach.

Related papers :

[1] L. Signor, A. Dragon, G. Roy, T. de Rességuier, F. Llorca, accepted in Archives of Mechanics, 2008.
[2] T. de Rességuier, L. Signor, A. Dragon, P. Severin, M. Boustie, J. Appl. Phys. 102, 073535, 2007.
[3] T. de Rességuier, L. Signor, A. Dragon, M. Boustie, G. Roy, FL. Llorca, J. Appl. Phys. 101, 013506, 2007.
[4] L. Signor, T. de Rességuier, G. Roy, A. Dragon, F. Llorca, SCCM conference proceedings, Elert, Chau, Holmes and Nguyen ed., AIP New York, p. 593, 2008.
[5] T. de Rességuier, L. Signor, A. Dragon, P. Severin, M. Boustie, SCCM conference proceedings, Elert, Chau, Holmes and Nguyen ed., AIP New York, p. 509, 2008.