LOW-VELOCITY SPALL TESTING OF TI-6AL-4V ALLOY AND NEW SPALL CRITERION BASED ON MESOSCALE

Second interim Report
(Sept.17/2002 – Dec.16/2002)

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This Interim Report covers the contract period from Sept. 17/2002 to Dec. 16/2003 (the second period of three months).The research in this Project is directed toward better understanding of the fracture process due to the local plastic fields occurring in mesoscale during spalling of Ti-6Al-4V alloy. Preliminary planar impact tests have been performed using specimens in the form of disks of different thickness and DIA 57.0 mm delivered by AMSRL-WM-TA, APG Aberdeen, MD. The plate-plate facility is in the stage of functioning after some period of preparation. A methodology of observation of the fracture surfaces after spalling on the mesoscale has been prepared. More exactly, the surface topography after spall fracture has already been analyzed for an aluminum alloy (preliminary analysis) and some statistics programs were tested. A new, high resolution profilometer, based on the light interference: WYKO NT1000 by VEECO has been applied in this part of the Project. The profilometer is equipped with a software which permits for variety of statistical analyses. This software permits for a detailed analysis of profiles in 3D. The 3D profiles will be compared with the scanning microscope data for the same areas. An additional series of the improved Direct Impact Shear Test has been performed for Ti-6Al-4Valloy. The test results obtained from DIST at high strain rates ~10^5 1/s will be applied to identify the material constants in new temperature coupled model of spalling based on mesoscale..

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EXTENDED ABSTRACT

During the second period (three months from Sept.17/2002 to Dec.16/2002) of the Contract the technical objective was to improve all the experimental setups and to put into operation the planar impact facility (impact plate on plate) and to perform preliminary tests with Ti-6Al-4V alloy. In addition, the Modified Double Shear experiments, [1], by direct impact have been continued for the same Ti alloy with an improved method of specimen attachment. The main purpose of this research is to clarify, using spall experiments, the role of short-time local plastic fields occurring in the meso-scale in material failure at very short time intervals. The thermal coupling and the local high strain rates will be considered in the modeling.

The Laboratory of Physics and Mechanics of Materials is equipped, besides Hopkinson bars in compression and torsion, in the plate impact facility with bore diameter 57 mm. A flyer plate can be accelerated up to 800 m/s depending on the gas that is used. A series of preliminary spall tests have been performed at different target/flyer thickness and different impact velocities. A critical minimal impact velocity was sought when the incipient spall occurs at loading times from ~600 ns to ~2.5 μs. The specimens in the form of disks of different thickness and DIA 57 mm have been delivered by AMSRL-WM-TA, APG Aberdeen, MD.

An observation of the spalled surfaces of TI-6Al-4V is in preparation, more exactly the surface topography in 3D. The new, high resolution profilometer, based on the light interference: WYKO NT1000 by VEECO, has been applied to determine 3D surface characteristics for an Al alloy as a preliminary study. This profilometers is equipped in a sophisticated software which has been already tested. The software permits for a detailed analysis of the surface profiles in 3D including statistics.

After previous research projects on Ti-6Al-4V supported by the European Research Office of the US Army an ample data are available obtained via the fast shearing, including additional tests performed recently, which will permit to identify all material constants in a constitutive relation developed in LPMM.

Our recent works toward understanding fracture in the meso-scale constitute a base for further studies. A new mesoscale model of fracture has already been applied to armor steels and hard aluminum alloy, [2,3]. The new model of spall fracture will be applied for Ti-6Al-4V based on the plate impact experiments, microscopic observations and topography analysis.

Refernces

[1] J.R.Klepaczko, An Experimental Technique for Shear Testing at High and Very High Straun Rates. The Case of a Mild Steel, Int. J. Impact Engng, **15** (1994), 25.

[2] P;Chevrier and J.R.Klepaczko, Spall fracture, mechanical and microstructural aspects, Eng. Fract. Mech., **63** (1999), 273.

[3] J.R.Klepaczko and P.Chevrier, Fracture dynamics in one-dimensional strain, in: Modeling of Damage and Fracture Processes in Engineering Materials, IFTR, Warsaw, Poland, (1999), 90.

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