2010-2011

Graduate Seminar Series

The Department of Mechanical Engineering – Engineering Mechanics

Proudly Presents

Dr. Brian McDonald
U. S. Army

Brian McDonald received his BSAE, MSME, and Ph.D from the Georgia Institute of Technology and has 22 years of experience in rocket propulsion design and analysis. He worked for 17 years at Stone Engineering in Huntsville, AL serving 4 years as the vice president and technical director. He served 3 years as a lecturer and member of the graduate faculty in the Department of Mechanical and Aerospace Engineering at the University of Alabama in Huntsville, and briefly worked in the University of Alabama's Center for Modeling, Simulation, and Analysis. He presently serves as a senior research engineer in the U.S. Army's Aviation, Missile, Research, Development, and Engineering Directorate's Propulsion Laboratory. His primary areas of research are in numerical combustion, and the thermal and mechanical aging of nitrate ester propellants. For the past two years his research has focused on the development of non-destructive health monitoring devices for nitrate esters to include carbon nano-tube gas sensors, and optical devices. He is a registered professional engineer in the state of Alabama.

Thursday, Oct. 14, 2010 4:00 – 5:00 p.m. Room 112, ME-EM Bldg.

On-going Studies of Chemical Aging of Nitrate Ester Solid Propellants and Health Monitoring Sensor Development

The primary aging mechanism of nitrate ester propellants include several steps that begin with the thermal decomposition of the nitrate ester and lead to, if unmitigated, the evolution of several gas species to include CO2, and NO2. These gases may lead to internal fissuring of the propellant or autocatalytic decomposition and combustion. Stabilizers are added to the propellants to neutralize the decomposition products and minimize the gas production. These stabilizers are consumed with aging with the service life of a particular propellant system determined as the time that the stabilizer mass fraction is consumed below a minimum acceptable level. The U.S. Army WDI directorate has an on-going technology program for the development of a service life monitoring system that incorporates non-destructive sensors for the monitoring of nitrate ester aging. This presentation presents an update of sensor/propellant aging test results, and the results of a series of nitrate ester humidity aging results that have been completed to date. The effects of aging under controlled humidity on the thermal decomposition of two nitrate ester/RDX propellants are examined. Propellant samples are accelerated aged at 60 °C and 70 °C at various levels of relative humidity. Differential Scanning Calorimetry is used to study the post aged samples to determine the activation energy of the peak exotherm and peak temperature of these events. Nitrate ester stabilizer depletion rates are presented as a function of aging and humidity. The results of the study show that that moisture level during aging irreversibly alters the activation energy of the primary heat release events and significantly influences the stabilizer depletion rates. In addition, humidity effects on the deterioration of the mechanical properties of the nitrate ester are investigated. The acidic by-products of the thermal decomposition of the nitrate ester plasticizers and hydrolyzed binder combine with the available excess moisture leading to the acidic catalyzed hydrolytic decomposition of the binder polymer reducing the cross-link density, elastic modulus and the strain endurance of the composite material. Dynamic Mechanical Analysis and polymer solvent swell testing are used to investigate the effect that the temperature and humidity induce aging has on the rheology of the polymer composite to include changes in cross link density, loss and storage modulus, and the glass transition temperature. A correlation of the change in these properties with the magnitude of the relive humidity of the aging environment is demonstrated. On-going propellant aging test results using carbon nano-tube gas sensors as a health monitoring device are presented.

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