MASTER OF SCIENCE
IN
MECHANICAL ENGINEERING

DEVELOPMENT OF A SIMSMART BASED,
PROGRESSIVE FLOODING DESIGN TOOL

Thomas J. Anderson-Lieutenant, United States Navy
B.S., Boston University, 1990
Master of Science in Mechanical Engineering-March 1999
Advisors: Charles N. Calvano, Department of Mechanical Engineering
Fotis Papoulias, Department of Mechanical Engineering

While the Navy addresses the effects of progressive flooding in its design requirements, its limits for damaged stability are the results of World War II damage analysis and are evaluated under static conditions, without regard for shipboard damage control systems. This thesis develops a program which utilizes the SIMSMART flow analysis program in tandem with naval architecture analysis in Microsoft Excel, to simulate progressive flooding of a ship based on the varying specifics of a given scenario. This program can be used to aid designers in dynamic simulation of the flooding process not only to determine the adequacy of dewatering equipment, but also to establish a timeline, including naval architecture parameters, throughout the process.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Surface/Under Surface Vehicles – Ships and Watercraft, Modeling and Simulation

KEYWORDS: Progressive Flooding, Damaged Stability, Simulation Based Design Tool

USE OF PRINCIPAL COMPONENT ANALYSIS FOR THE IDENTIFICATION
AND MAPPING OF PHASES FROM ENERGY-DISPERSIVE X-RAY SPECTRA

Daniel John Chisholm-Lieutenant, United States Navy
B.S., Renesselaer Polytechnic Institute, 1990
Master of Science in Mechanical Engineering-March 1999
Advisor: Alan G. Fox, Department of Mechanical Engineering

Multivariate statistical analysis methods such as Principal Component Analysis (PCA) are now finding applications in electron microscopy including the analysis of energy dispersive x-ray spectra (EDS). The aim in this thesis is to extend EDS beyond its conventional use in the measurement of elemental distributions to allow both the identification of chemical phases and the mapping of their distribution.

In the present work, PCA was applied to the analysis of modeled spectra representing interfaces where diffusion and/or an interface reaction had occurred. A search routine was developed to find physically possible interface phases using the principal components found by PCA. From the modeled data, it was shown that an interface phase could, in principle, be found using PCA but that it is embedded in a cluster of physically possible spectra. The technique was then applied to experimental data obtained from an interface between chemically vapor deposited diamond (CVDD) and Cr_2O_3. The results followed the same pattern as was seen with the modeled data. Criteria for experimental EDS spectra other than those used to define a physically meaningful spectrum are discussed. These should help further limit the cluster of possible answers found allowing a correct determination of the real interface phase.

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structures

KEYWORDS: Multivariate Statistical Analysis, Principal Component Analysis, Energy Dispersive X-Ray Spectra

PROGRESSIVE FAILURE MODELING IN NOTCHED CROSS-PLY FIBROUS COMPOSITES

Linda E. Craugh-Lieutenant, United States Navy
B.S., Cornell University, 1991
Master of Science in Mechanical Engineering-March 1999
Advisor: Young W. Kwon, Department of Mechanical Engineering
Second Reader: Terry R. McNelley, Department of Mechanical Engineering

The objective of this study was to model and simulate progressive failure initiating from a notch tip in a laminated fibrous composite subjected to tensile in-plane loading. The micro/macro-level approach was used for this study. The micro-level analysis used the 3-D unit cell model while macro-level analysis used the finite element analysis technique. A cross-ply laminate with double-edge notches was studied to investigate delamination, fiber splitting, and transverse matrix cracking in the structure. Numerical results were compared to previous experimental work.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Materials, Processes, and Structures

KEYWORDS: Finite Element Method, Composite Micromechanics, Delamination

FINITE ELEMENT MODEL UPDATING AND DAMAGE DETECTION USING ARTIFICIAL BOUNDARY CONDITIONS

Christopher P. DeGregory-Lieutenant, United States Navy
B.S., Worcester Polytechnic Institute, 1991
Master of Science in Mechanical Engineering-March 1999
Advisor: Joshua H. Gordis, Department of Mechanical Engineering

Natural Frequencies of a system are identified by applying artificial boundary conditions at measurement locations and obtaining the frequency response function for the unrestrained degrees of freedom. The frequencies of the system under a variety of boundary conditions can be found without any physical alterations of the test boundary conditions. This approach is applied to model updating and sensitivity-based damage detection.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Finite Element Model

VALIDATION OF ENHANCED MIXING EDUCTOR DESIGNS FOR GAS TURBINE EXHAUST SYSTEMS

Adam W. Masten-Lieutenant, United States Navy
B.S., United States Naval Academy, 1992
Master of Science in Mechanical Engineering-March 1999
Mechanical Engineer-March 1999
Advisor: Knox Millsaps, Department of Mechanical Engineering

The performance of two newly designed, enhanced mixing exhaust gas eductor nozzle patterns was measured and analyzed. Both designs use a constant area square mixing tube and 16 high aspect-ratio slot nozzles which promote rapid mixing, reducing the required mixing tube length. One design uses arrays of parallel nozzles while the other uses a radial nozzle arrangement. A one-fifth scale, cold flow air tunnel facility was designed and constructed. The secondary-to-primary air entrainment ratios and mixing tube exit velocity profiles are reported for a range of mixing tube standoff distances. An analysis of the results is provided along with projections for hot flow performance.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Modeling and Simulation, Other (Signatures)

KEYWORDS: Modeling and Simulation, Gas Turbine Exhaust, Eductors, Mixing, Cold flow Testing

EFFICIENT COMPUTATION OF NONLINEAR TRANSIENT STRUCTURAL SYNTHESIS FOR SEISMIC ISOLATION

Cliff P. Pearce-Lieutenant, United States Navy
B.S. United States Naval Academy, 1991
Master of Science in Mechanical Engineering-March 1999
Advisor: Joshua H. Gordis, Department of Mechanical Engineering
Second Reader: Terry R. McNelly, Department of Mechanical Engineering

A method of structural synthesis is presented using a recursive computational process. A structure can be modeled entirely linearly, with localized nonlinearities included as synthesized forces. The method allows retention of only the degrees of freedom (DOF) of interest, including, at a minimum, the DOF at which nonlinearities are applied. The method is illustrated using an *n*- degree of freedom finite element model of a simple structure. The method is shown to adjust the response of the system based on addition of a nonlinear base isolator. Finally, the method is compared to MATLAB's ODE45 function as a measure of accuracy and efficiency. The method is theoretically exact, and results in order of magnitude decreases in computational time for modification analysis.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Civil Engineering, Nonlinear, Shock Isolation)

KEYWORDS: Optimization, Nonlinear Isolation, Shock Isolation, Nonlinear Shock Isolation

A FEASIBILITY STUDY OF LIQUID PHASE SINTER FORMING OF A MODEL CERAMIC SYSTEM

Roland C. Roeder-Lieutenant, United States Navy
B.S.N.E., Purdue University, 1990
Master of Science in Mechanical Engineering-March 1999
Advisors: Indranath Dutta, Department of Mechanical Engineering
Ashok Gopinath, Department of Mechanical Engineering

The feasibility of a new manufacturing process of ceramic materials in which net shaped products are produced via sintering and simultaneously deforming is studied. A suitable model system of SiO_2-B_2O_3 is chosen due to its desirable properties for liquid phase sintering and its ability to be tested under atmospheric conditions. Samples of compacted powder are prepared and characterized via x-ray diffraction and scanning electron microscopy. Tests to determine the ability of the system to undergo Liquid Phase Sintering are studied. Deformation of samples in compression with concomitant Liquid Phase Sintering at nominally constant true strain rates is performed, and the effects of the amount of liquid phase present are investigated. Problems associated with the Liquid Phase Sinter Forming process are identified, and recommendations are suggested for future studies.

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structures

KEYWORDS: Liquid Phase Sintering, SiO_2, B_2O_3, Silica, Silicon Dioxide, Boron Oxide, Deformation, Superplasticity, Ceramic, Powder Processing, Deformation in Presence of a Liquid Phase

ENHANCEMENT OF BOILING IN HIGHLY WETTING FLUIDS

Joseph M. Tuite-Lieutenant, United States Navy
B.S., United States Naval Academy, 1992
Master of Science in Mechanical Engineering-March 1999
Advisor: Matthew D. Kelleher, Department of Mechanical Engineering

The boiling of a highly wetting dielectric fluid, in an oscillating fluid environment, has been investigated. Because of low surface tension, these liquids require very high superheat to initiate nucleate boiling. This high degree of superheat required can be reduced by oscillation of the fluid. This oscillation removes the bubbles, which are forming in the nucleation sites on the wire, which allows new bubbles to form. The amplitude and frequency of the oscillation has been varied in an attempt to find the optimum values.

All attempted oscillation amplitudes and frequencies reduced the required superheat necessary to initiate nucleate boiling. Some oscillation amplitudes and frequencies were more effective than others. No global optimum amplitude or frequency was specifically located. Several local optimum values were found. One oscillation amplitude was found to produce equal required superheat values at various frequencies, thus appearing to be independent of frequency.

DoD KEY TECHNOLOGY AREAS: Electronics, Other (Cooling Systems)

KEYWORDS: Boiling Enhancement Techniques

SPRAY GENERATION FROM FREE AND HALF-FREE JETS

Rajan Vaidyanathan-Lieutenant, United States Navy
B.S., Punjabi University, 1987
Master of Science in Mechanical Engineering-March 1999
Advisor: Turgut. Sarpkaya, Department of Mechanical Engineering

This is an experimental investigation of the ligament and drop formation at the free surface of wall jets, flowing over sand-roughened plates, and on unbounded two-dimensional jets, discharging into atmosphere. Experiments were conducted with both fresh and simulated sea water. Measurements were made with several high-speed imagers and a pulsating laser system and analyzed through the use of appropriate software. The wall-jet Reynolds number ranged from 3.5x103.5x10^4 to 8.5x10^4, the Froude number from 15 to 30, and the Weber number from 3,000 to 7,500. The positions of the transition and primary breakup as well as the characteristics of the ligament forest and droplets were determined from the digitized images and interpreted in terms of the characteristics of the turbulent boundary layer and a phenomenological model based on the observations and measurements. The emphasis has been on the physics of the phenomenon rather than on the development of empirical relationships.

DoD KEY TECHNOLOGY AREA: Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: Spray, Drops, Bow sheets, Turbulent boundary layers, Liquid sheets

LOW COST AUV HEADING REFERENCE USING A TCM2 ELECTRONIC COMPASS MODULE

Shawn E. White-Lieutenant, United States Navy
B.S., University of Texas at Austin, 1991
Master of Science in Mechanical Engineering-March 1999
Advisor: Anthony J. Healey, Department of Mechanical Engineering

One of the greatest challenges concerning submerged Autonomous Underwater Vehicle (AUV) operations involves developing an accurate and reliable navigation control system. Although several established solutions exist, the equipment is cost prohibitive. By utilizing the advances realized by industry in compass technology, a low-cost and reliable compass module can be incorporated into the AUV navigation system. This “commercial-off-the-shelf” (COTS) equipment has inherent errors associated with interaction with the host vehicle, but data analysis of compass output and numerical corrections to the control system can improve the accuracy of heading references needed by the AUV navigation control in very shallow water. This thesis examines the feasibility of using a TCM2 electronic compass with error correction in the Naval Postgraduate School’s Phoenix AUV.

DoD KEY TECHNOLOGY AREA: Surface/Under Surface Vehicles-Ships and Watercraft

KEYWORDS: AUV, Electronic Compass, Compass Navigation, TCM2, COTS, Deviation Table, Fourier Analysis, Polynomial Approximation, Calibration