MASTER OF SCIENCE
IN
MECHANICAL ENGINEERING

OPTIMAL DESIGN OF NONLINEAR SHOCK ISOLATION
FOR LARGE, LOCALLY NONLINEAR STRUCTURAL SYSTEMS

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The method of Time Domain Structural Synthesis is reviewed and examples of linear structural modification and sub-structure coupling are presented. The general formulation for both linear and nonlinear syntheses are compared to highlight the similarities between the two and the difficulties experienced with the introduction of nonlinear elements. Examples of linear and nonlinear sub-structural coupling are presented to emphasize the similarity of the procedures used. Finally, a general approach for the optimal design of nonlinear shock isolation for large structural systems is developed. The repeated solution of arbitrarily large finite element models with localized nonlinear components is made possible through the use of a highly efficient nonlinear transient re-analysis procedure. The method has demonstrated order of magnitude decreases in compute time over traditional direct integration methods and is exact, regardless of the nature of the isolation. An example is included which demonstrates the procedure.

DoD KEY TECHNOLOGY AREAS: Surface/Underwater Surface Vehicles-Ships and Watercraft, Ground Vehicles, Modeling and Simulation, Other (Nonlinear Shock Isolation Civil Engineering)

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

MICROSTRUCTURAL CHARACTERIZATION OF Ti-44Al-11Nb IN THE
CHILL-CAST AND DIRECTIONALLY SOLIDIFIED CONFIGURATIONS

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The microstructural evolution in chill-cast and directionally solidified Ti-44Al-11Nb (at.%) was studied by x-ray diffraction (XRD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM) methods. From this data, the microstructural distribution and formation sequences of various phases like Al_3Ti, TiAl, and Ti_3Al were established. The elemental and phase distributions were determined by TEM with energy dispersive x-ray spectroscopy (EDX) and spectrum imaging. Both casting techniques produced the same phases, (Al_3Ti, TiAl, and Ti_3Al with some Nb in solid solution), but the microstructural distribution was markedly different. The chill-casting technique resulted in a coarser microstructure, with large γ crystals and duplex regions of either ($\gamma + \alpha_2$) or ($\gamma + Al_3Ti$) interspersed throughout the alloy. The directional solidification technique resulted in a much more uniform microstructure with fine lamellar grains in a dendritic macrostructure. Both casting techniques showed enrichment of niobium in interdendritic regions.

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structures

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KEYWORDS: Gamma-Titanium-Aluminum Alloys, Niobium, Intermetallics, Microstructure, Scanning Electron Microscopy, Transmission Electron Microscopy

BIOMECHANICAL RESPONSE OF THE HUMAN BODY INSIDE A MILITARY VEHICLE EXPOSED TO MINE EXPLOSION

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Biomechanical response of the human body inside a military vehicle exposed to AP mine explosion was studied using the finite element method. The main focus was placed on evaluation of the injury potential of the human body, particularly the brain, neck (cervical spine), and legs. Injury criteria used to evaluate the injury potential were Head Injury Criteria (HIC), Injury Assessment Reference Values (IARVs), and some others. The military vehicle used in this research was M1097A2, the basic model of HUMVEE. In addition to the evaluation of the injury potential, some design modifications to the present vehicle are included.

DoD KEY TECHNOLOGY AREAS: Biomedical, Ground Vehicles, Modeling and Simulation

KEYWORDS: Biomechanical Response, Injury Potential, AP-Mine

DETERMINATION OF DIESEL ENGINE CYLINDER GAS TORQUES FROM SPEED FLUCTUATIONS WITH A HIGH-FIDELITY CRANKSHAFT TORSIONAL MODEL

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An experimental investigation was conducted to develop a method of predicting cylinder indicated torques in a reciprocating engine by measurement of crankshaft angular velocity fluctuations. Cylinder indicated pressures were measured for all three cylinders of a two-stroke diesel engine with pressure transducers. Time-resolved angular position was measured at the crankshaft front and at the flywheel. A six degree-of-freedom torsional crankshaft model was developed. Two solution methods are described to solve the equations of motion: a time-marching ODE solver, and a Finite Element solution in the time domain. Using these methods with the measured cylinder torques, the angular positions are predicted and compared to measured angular positions for model calibration. An inverse solution method was developed to determine the cylinder indicated torques from the measured angular position at the crankshaft endpoints. The method is theoretically demonstrated to be useful for explicit solutions for two-stroke engines up to three cylinders, and four-stroke engines up to four cylinders. Experimental results show that the method is useful in predicting cylinder indicated torques from angular velocity measurements.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles, Ground Vehicles, Modeling and Simulation

KEYWORDS: Diesel Engine, Crankshaft Angular Velocity, Cylinder Indicated Pressure, Torsional Model

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

AN ELECTRON BACKSCATTER DIFFRACTION ANALYSIS OF THE MICROSTRUCTURE OF PURE ALUMINUM PROCESSED BY EQUAL-CHANNEL ANGULAR PRESSING

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Equal-channel angular (ECA) pressing is a promising method to achieve refinement of grain size to 1.0 m or less for aluminum and its alloys. Computer-aided electron backscatter diffraction (EBSD) analysis of high purity aluminum (99.99%) which had been subjected to one pass, four passes, and twelve passes through an ECA die was performed. Grain and subgrain size and boundary misorientation distributions during such large-strain deformation processing were of particular interest. A texture was present after one pressing and the boundary misorientation distribution had a peak at $5^0 - 10^0$ although boundaries were present in all misorientation ranges. Fine equaixed grains were achieved after twelve passes through the ECA die, accompanied by random orientation and misorientation distributions.

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structures

KEYWORDS: Equal-Channel Angular Pressing, Electron Backscatter Diffraction, Grain Refinement, Sub-Micrometer Grain Refinement, Massive Deformation, Plastic Deformation, Deformation Banding, Boundary Misorientation, Preferred Misorientation Angle