MASTER OF SCIENCE IN MECHANICAL ENGINEERING

EXPERIMENTAL STUDY OF ZERO MEAN OSCILLATORY FLOW FORCES ON CIRCULAR CYLINDERS

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This thesis examines the forces in a zero mean current oscillatory fluid flow on circular cylinders. Experimental force data on different sized aluminum rods exposed to a standing acoustic wave in a nitrogen filled acoustic chamber is obtained from suitably mounted strain gages. Drag, inertia, and lift coefficients and KC, Reynolds, and beta numbers are determined, and the rods' temporal and spatial deformations are examined. The use of high nitrogen pressures reduces kinematic viscosity yielding high Reynolds number flow regimes. This technique can be used in the prediction of forces on ocean structures exposed to oscillatory flows.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Marine and Offshore Structures)

KEYWORDS: Oscillatory Flow, Acoustic Standing Wave, Sea Forces, Offshore Structures, Cable Runs, Structural Response, Drag Coefficient

INVESTIGATION OF BIOMECHANICAL RESPONSE DUE TO FRAGMENT IMPACT ON BALLISTIC PROTECTIVE HELMET

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Technology has increased dramatically over the last 25 years. It has allowed the development of personnel body armor capable of preventing penetration of fragments traveling in excess of 2000 ft/s (609 m/s). However these strides have also exposed the body to greater impact energies without a lethal penetration. The objective of this research was to examine how the body in particular the Head-Neck Complex responds to these impacts. A finite element model was developed to characterize the behavior of this biomechanical system. This model was then validated against existing experimental work from the automotive industry. The validated model was then subjected to impacts at different positions to induce different load cases. Each set of results was then compared to Head Injury Criteria (HIC), Abbreviated Injury Scale (AIS), and the Injury Assessment Reference Values (IARVS) for evidence of injury potential. Disc stiffness was found to be proportional to the injury potential. Rupture of the disc was considered likely for five of the six cases examined. Fracture of the vertebral body was considered likely in three of the six cases. Suggestions for future research are included in the hopes of furthering research into this area.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Finite Element Modeling, Spine, Cervical, Biomechanics, Body Armor

EVALUATION OF MICROSTRUCTURE OF A 6092 Al -17.5 VOLUME PERCENT SiC PARTICLE REINFORCED COMPOSITE USING ELECTRON BACKSCATTER PATTERN (EBSP) ANALYSIS METHODS

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Microtexture and grain boundary misorientation data were obtained for a 6092 Al - 17.5 volume percent SiC particle-reinforced material as a function of processing history. Computer-aided electron backscatter pattern (EBSP) analysis methods in a scanning electron microscope were used to obtain grain-specific orientation measurements by traversing along a pattern of lines on the surface of a metallographic sample. As part of this project, it was necessary to develop ion milling methods to obtain a sufficiently strain free condition of the aluminum matrix to allow diffraction patterns to be obtained. These methods were applied to samples extruded at various strain rates and processing temperatures; the data revealed that recrystallization had occurred at all processing conditions. Analysis of crystal orientations and grain-to-grain misorientation data revealed random distributions consistent with predictions of the particle-stimulated nucleation theory of recrystallization. Additionally, spacing measurements were taken between orientation measurements. The result of this analysis indicated a very fine matrix microstructure.

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structures

KEYWORDS: Discontinuous Reinforced Aluminum, Metal Matrix Composites, Matrix Microtexture, Electron Backscatter Pattern, Preferred Grain Orientation and Texture, Grain Misorientation, Recrystallization, Particle-Stimulated

FREQUENCY MODULATION TECHNIQUE FOR MACHINERY NOISE REDUCTION

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A ship's or submarine's acoustic signature is often characterized by the low frequency narrow band noise components of its rotating machinery. By reducing or altering machinery noise components, a naval vessel can reduce its vulnerability to detection and classification. This study presents and evaluates the frequency modulation technique as a potential method to reduce machinery narrow band noise levels.

The research examines both the experimental and numerical implementation of frequency modulation for the case of rotating machinery. Specifically, a dc motor's operating frequency is modulated about a center frequency of 50 hertz by adding a sinusoidally varying voltage to the base voltage. The amplitude and frequency of the sinusoidal signal are varied and the resultant effects on the noise spectra are studied. Experimental results demonstrate that machinery narrow band signatures may be reduced at the expense of elevated broad band levels. The numerical simulation characterizes general trends and the relative reductions obtainable with frequency modulation.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation, Other (Vibration Reduction)

KEYWORDS: Frequency Modulation, Vibration Reduction, Noise Reduction, Permanent Magnet Motor, Quieting

EVALUATION OF THE MECHANICAL PROPERTIES AND EFFECTIVENESS OF COUNTERMINE BOOTS

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The first goal of this project was to determine the mechanical properties of countermine boots and protective overboots that are currently available to U.S. soldiers. The second goal of this project was to conduct a qualitative analysis to determine the effectiveness of the boots. This was done by determining their ability to dissipate a blast force equivalent to a typical anti-personnel landmine. This was followed by a parametric study which involved altering the component materials in an effort to determine if the effectiveness of the boots varied as the materials changed.

The soles of both boots were made from identical materials. All the materials used in the boots' soles were tested to determine their mechanical material properties using an Instron uniaxial testing machine. All testing was conducted on multiple specimens to verify repeatability. The material data was tabulated and the stress-strain curves are included in this report.

A finite element analysis was conducted to evaluate the effectiveness of the countermine boot based upon accepted tolerance levels of the lower bones of the body. Next, the materials and their dimensions were modified in the finite element model to determine how these modifications would impact the boots' effectiveness.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Biomechanical)

KEYWORDS: Finite Element Method, Material Properties, Mechanical Testing

PRELIMINARY DESIGN STUDY FOR AN ENHANCED MIXING EDUCTOR FOR GAS TURBINE EXHAUST SYSTEMS

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A preliminary design study was conducted to scale the geometry for a new, enhanced mixing eductor for gas turbine exhaust systems. An analytical model was developed to predict the secondary flow and hence the exhaust temperature at the exit to the mixing tube. The model consists of an ideal one-dimensional flow model with a correction factor applied to the secondary mass flow. This factor was chosen to match existing experimental data. This calibrated model was then used to perform a design study to scale the cross sectional areas and assess pressure loss versus performance. A concept with a square mixing tube and multiple high aspect ratio primary nozzles was developed and the baseline geometry was scaled. Two primary nozzles pattern arrangements are provided that should obtain the required mixing in the reduced length.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Surface Ships)

KEYWORDS: Modeling and Simulation, Gas Turbines, Eductors