MECHANICAL ENGINEER

THE EFFECT OF THERMOMECHANICAL PROCESSING ON THE TENSILE PROPERTIES AND MICROSTRUCTURE OF A 6061 AL-AL_2O_3 METAL MATRIX COMPOSITE

Michael Alan Ballou-Lieutenant, United States Navy
B.S., United States Naval Academy, 1989
Mechanical Engineer-December 1995
Advisor: Terry R. McNelley, Department of Mechanical Engineering

This work includes a comprehensive analysis of the effect of thermomechanical processing (TMP) history on the microstructure and properties of 10 and 20 volume percent 6061 Al-Al_2O_3 discontinuous metal matrix composites (MMCs). Materials in which cold drawing and annealing operations were included in the TMP demonstrated increased ductilities for a given strength level when compared to materials which were processed by hot extrusion only. Microstructural analysis provided clear evidence of the absence of damage to reinforcing particles during TMP and of load transfer to these particles during subsequent straining. Failure during tension testing resulted from the ductile tearing of the matrix as voids, initiated by the cracking of reinforcement particles, joined together. A distinct microstructural difference related to processing history was the development of a strongly fibered particle distribution in materials experiencing low temperature drawing operations. In order to conduct an analysis of the mechanisms by which the particles are redistributed and reoriented during processing, a channel compression die was constructed which allowed processing to be simulated by compressive straining on a mechanical testing machine. This allowed careful control of the processing parameters. An analysis of the effects of processing temperature on particle redistribution and reorientation was conducted.

INTERACTION OF A SWIRLING JET WITH A FREE SURFACE

Michael S. Feyedelem-Lieutenant, United States Navy
B.S.N.E., Purdue University, May 1989
Mechanical Engineer-March 1996
Master of Science in Mechanical Engineering-March 1996
Advisor: T. Sarpkaya, Department of Mechanical Engineering

The turbulent flow field of a swirling jet issuing from a nozzle, beneath and parallel to a free surface has been studied in as much detail as possible using a three-component laser Doppler velocimeter and flow visualization. The results have shown that the swirl leads to the faster spreading and quicker mixing of the jet. For strongly swirling jets (S = 0.522), the similarity is not reached within ten diameters downstream. The results have also shown that both the axial and tangential velocity components decrease outward from the jet axis, naturally leading to centrifugal instabilities. This, in turn, leads to the creation of large scale coherent structures at the periphery of the jet, particularly when it is in the vicinity of the free surface. The turbulent shear stresses exhibit anisotropic behavior, the largest always being in the plane passing through the jet axis. The change of TKE with S is not monotonic. It is maximum for S = 0.265, smallest for S = 0.50, and has an intermediate value for S = 0.522. This is due to the occurrence of vortex breakdown and the resulting intensification of the turbulence within the jet prior to its exit from the nozzle.

OPTIMAL SOLUTION SELECTION FOR SENSITIVITY-BASED FINITE ELEMENT MODEL UPDATING AND STRUCTURAL DAMAGE DETECTION

Jay A. Renken-Lieutenant Commander, United States Navy
B.S., University of Illinois, August 1983
Mechanical Engineer-December 1995
Master of Science in Mechanical Engineering-December 1995
Advisor: Joshua H. Gordis, Department of Mechanical Engineering

The finite element model has become the standard way in which complex structural systems are modeled, analyzed, and the effects of loading simulated. A new method is developed for comparing the finite element simulation to experimental data, so the model can be validated, which is a critical step before a model can be used to simulate the system.

An optimization process for finite element structural dynamic models utilizing sensitivity based updating is applied to the model updating and damage detection problems. Candidate solutions are generated for the comparison of experimental frequencies to analytical frequencies, with mode shape comparison used as the selection criteria for the optimal solution. The method is applied to spatially complete simulations and to spatially incomplete experimental data which includes the model validation of a simple airplane model, and the damage localization in composite and steel beams with known installed damage.

STUDIES ON SUBMARINE CONTROL FOR PERISCOPE DEPTH OPERATIONS
John Vincent Tolliver-Lieutenant, United States Navy
B.S., Montana State University, 1988
Master of Science in Mechanical Engineering-September 1996
Mechanical Engineer-September 1996
Advisor: Fotis Papoulias, Department of Mechanical Engineering

Requirements for submarine periscope depth operations have been increased by integration with carrier battle groups, littoral operations, and contributions to joint surveillance. Improved periscope depth performance is therefore imperative. Submarine control personnel rely on a large number of analog gauges and indications. An integrated digital display system could enhance the ergonomics of the human control interface and display additional parameters. This thesis investigates the required feedbacks for robust automatic depth control at periscope depth, and thus indirectly determines the additional parameters desired for an integrated display.

A model of vertical plane submarine dynamics is coupled with first and second order wave force solutions for a particular submarine full form. Sliding mode control and several schemes of state feedback are used for automatic control. Head and beam seas at sea states three and four are investigated. The automatic control effectiveness provides insight into the indications used by the ship's control party in operations at periscope depth. One possible display system is proposed, with several additional enhancements to improve ship's safety, reduce operator fatigue, and enable accurate reconstruction of the events leading to a loss of depth control.