MASTER OF SCIENCE
IN
MECHANICAL ENGINEERING

PHASE SINTER FORMING OF A MODEL CERAMIC SYSTEM

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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: Ceramic Powder Processing, Liquid Phase Sintering, High Temperature Deformation, Superplasticity in Ceramics, Creep Mechanisms, Deformation in the Presence of a Liquid Phase

ANALYSIS OF UNDERBEAD CRACKING IN UNDERWATER WET WELDMENTS ON A516 GRADE 70 STEEL

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The use of underwater weldments on U.S. Naval Vessels is highly desirable due to the ability of performing repairs without costly dry dock expenses. The primary problem with underwater wet weldments is underbead cracking in the heat affected zone (HAZ). The fundamental factors causing underbead cracking in underwater wet weldments using a shielded metal arc welding (SMAW) process are high quench rates, slag inclusions, diffusible hydrogen levels and porosity.

The weld metal analysis included use of optical and scanning microscopy as well as microhardness testing. Three weld samples made at 5°C, 12°C, and 25°C water temperature were analyzed in this thesis. HAZ underbead cracking was present in all three welds analyzed although the 5°C sample was the only weld that exhibited extensive cracking whereas the 25°C sample only had cracking near the upper 50% of the weld passes. Crack origination in all three samples near the cap was evident and was most likely due to small levels of bead tempering at this location.

This thesis addresses the mechanisms of the cracking as well as the effects of diffusible hydrogen, cooling rates, and water temperatures on wet weldments.

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DoD KEY TECHNOLOGY AREAS: Materials, Processes, and Structures, Surface/Under Surface Vehicles – Ships and Watercraft

KEYWORDS: Underwater Wet Welding, Hydrogen Cracking, Underbead Cracking, Non-Metallic Inclusions, Shielded Metal Arc Welding

APPLICATION OF NUMERICAL OPTIMIZATION TECHNIQUES TO SURFACE COMBATANT DESIGN SYNTHESIS

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This thesis presents the effort to incorporate a numerical optimizer into an existing ship design synthesis math model. The goal is to improve the functionality of the model while retaining the intrinsic value of the model's friendly user interface, which is greatly advantageous for its use as a learning tool. A description of the math model and its origin and intent are presented along with a discussion of numerical optimization techniques and tools. The integration and linking software is described along with the actual Integrated Ship Design System. Results of comparison and sensitivity studies are also presented.

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

KEYWORDS: Ship Design Synthesis, Numerical Optimization, MIT Simplified Math Model, Mathcad, Matlab Optimization, MathConnex, Objective Function, Constraint Function

BIAS EFFECTS ON MOTION STABILITY OF SUBMERSIBLE VEHICLES

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This thesis analyzes the nonlinear characteristics of motion stability of a submersible vehicle in combined sway, yaw, and roll motions. Previous results, at zero pitch angles, indicate that limit cycles are generated as a result of loss of stability. In this work, these results are extended to include nonzero pitch angles. This analysis can determine how changes in vehicle parameters and loading conditions will affect its operation and performance. Stability domains are generated for a variety of vehicle and environmental parameters. A nonlinear analysis is conducted in order to assess the stability characteristics of the resulting limit cycles. The results can lead to design guidelines for improving vehicle operational envelopes.

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

KEYWORDS: Roll, Sway, Yaw, Stability of Motion, Periodic Solutions, Bifurcations

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SENSITIVITY ANALYSIS OF DIVE PLANE REVERSAL OF SUBMERSIBLE VEHICLES AT LOW SPEEDS

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The capability of a submersible vehicle to accurately maintain its commanded depth in a variety of operating speeds, depths and loading conditions is critical for mission accomplishment. Below a certain critical speed a phenomenon known as dive plane reversal occurs, where depth response changes sign with respect to a given dive plane command. This thesis builds on previous studies of the phenomenon and it presents a comprehensive sensitivity study of dive plane reversal envelopes in the presence of external forces and moments on the vehicle. Based on these results, rational design and operational decisions can be made in order to avoid unpredictable vehicle responses.

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

KEYWORDS: Dive Planes, Critical Speed

CAVITATION EFFECTS ON A SHIP-LIKE BOX STRUCTURE SUBJECTED TO AN UNDERWATER EXPLOSION

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Shock trials are required for the lead ship of each new construction shock hardened ship class. Live fire shock trials are both complex and expensive. Finite element modeling and simulation provides a viable, cost effective alternative to live fire shock trials. This thesis investigates the effect of bulk and local cavitation on a three-dimensional ship-like box model. The fluid surrounding the structure will be modeled to capture the effect of cavitation. Viable results will validate the modeling and simulation method used and provide the basis for further investigation into the use of fluid modeling in underwater explosion simulation.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Surface/Under Surface Vehicles-Ships and Watercraft

KEYWORDS: Underwater Explosion, Cavitation, Surface Model

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IMPROVED COMPUTER MODELING OF SHIP PROGRESSIVE FLOODING AS A DESIGN TOOL

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When a ship suffers underwater damage, there is a rapid influx of water, followed by a period of slower progressive flooding. This results in flooding of compartments whose hull boundaries, but not interior bulkheads, are still intact. An existing computer model uses the FORTRAN computer language and formatted input files to model progressive flooding. This thesis uses MATLAB computer language and SIMULINK graphical user interface to provide a modular, expandable progressive flooding design tool.

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

KEYWORDS: Progressive Flooding, Computer Model