2019-12

Hydrocode Analysis of Seabed Effector Initiation Options

Didoszak, Jarema M.

Monterey, California: Naval Postgraduate School

http://hdl.handle.net/10945/69966

MONTEREY, CALIFORNIA

HYDROCODE ANALYSIS OF SEABED EFFECTOR INITIATION OPTIONS

Period of Performance: 10/15/2018–10/14/2019

Researchers:
Principal Investigator (PI): Mr. Jarema M. Didoszak, GSEAS, Mechanical and Aeronautical Engineering (MAE).

Prepared for:
Topic Sponsor Lead Organization: U.S. Fleet Forces Command
Topic Sponsor Organization: Commander, Submarine Force, U.S. Pacific Fleet (COMSUBPAC)
Topic Sponsor Name: Science Advisor, Dr. Stephen Turner
Topic Sponsor Contact Information: Stephen.e.turner1@navy.mil, 808-473-5650

NPS NRP Executive Summary
Hydrocode Analysis of Seabed Effector Initiation Options
Report Date: 11/01/19 Project Number (IREF ID): NPS-19-N079-A
Naval Postgraduate School, Graduate School of Engineering and Applied Sciences

EXECUTIVE SUMMARY

Project Summary
The use of implodable volumes as seabed effectors has shown promise based on past research and preliminary test results, however, their efficacy as replacements for conventional explosives within the desired operational space is yet to be fully determine. Through physics-based modeling and simulation it was found that the underwater explosion events throughout the design space performed as expected. However, while implosion events generated considerable pressure rise to the surrounding regions at depth, the amount of energy required to overcome the containing vessel significantly reduced the magnitude of the implosion-generated pressure front. Consequently, the collapsible volume required to generate a pressure loading equivalent to an explosive charge was greatly increased. Additionally, there was a time lag, and diminishing reach in the radial direction observed in the pressure propagation as compared to the conventional explosive charge. Further study is required into the initiation and response of directionally focused deep-sea implosion-initiated shock fronts which may overcome the lesser release of omni-directional volumes for an increased pressure loading on target bodies at depth.

Keywords: *underwater explosion (UNDEX), implosion, seabed effector*

Background
An underwater explosion (UNDEX) is characterized by the rapid release of energy from detonation of a high explosive, which results in a shock pressure wave front, while an implosion results is a radiating pressure pulse caused by the sudden energy release of a failed implodable volume under the water. The use of UNDEX and implosions, at depth, in the sea environment are both attractive means by which to maintain control of the undersea domain through the elimination of adversarial threats. While the phenomena associated with UNDEX has been studied much more extensively, especially since its devastating effects became evident during World War II, implosion effects are not yet characterized as well. In both cases the pressure loading, interaction between a delivery device and the seabed target ,and resulting damage effects, require further study so as to determine the most appropriate choice of initiator in a particular sub-sea setting.

Complicating this matter is the fact that seabed depths vary from the shallow waters of the surf zone all the way down to the abyss and even trenches that pass 10,000 meters in depth. Additionally, the delivery vehicle and other resources need to be preserved during such an operation. This is contrary to the typical implementation of both UNDEX and implosion events which radiate outward, providing an overpressure more or less uniformly in the horizontal plane with some differences in the vertical direction due to the effects of hydrostatic pressure.

Previous implosion research modeling and simulation has primarily focused on geometric properties of implodable volumes, such as cylinders and spheres, and the resulting pressure yield. Preliminary studies using 1D fluid models indicated a potential for implosion-initiated peak pressures to far exceed those of

UNDEX. However, the subsequent pressure loading and duration were also predicted to be lesser than that of the UNDEX equivalent. Translating these basic loading phenomena into damage mechanisms in order to defeat the target is still to be considered.
The current work expands on this by comparing high explosive source pressure yields derived from UNDEX to implosion-initiated pressure loading of air cavities and collapsible thin walled volumes of various geometries across the design space.

Findings and Conclusions

Physics based modeling and simulation supplemented by the analyses of previous studies indicates that there is potential in the implosion-initiated defeat of seabed targets. A design space survey of pressure loading both by initiator size (volume) and detonation depth was performed using the DYSMAS hydrocode. Peak pressure response at a distance at 10 charge radii from the source was used to compare the simulated explosion and implosion cases in 2D and 3D fluid domains. Pressure results were tabulated by depth, initiator type and other selectable parameters such as radius, length to diameter ratio, thickness and material properties.

Conventional underwater explosives are self-contained pressure release devices, bringing together both the initiation and chemical components required for detonation and subsequent combustion. They are relatively dense as compared to implodable devices, and thus less susceptible to variance in depth. These simulations produced results as expected. Their pressure yield was found to be in accordance with recognized formulae derived from empirically collected data. On the contrary, implodable volumes, which are less compact, require fine tuning of their structural casing based on the expected depth of operation, are more difficult to accurately predict. The cylindrical geometry was found to be superior in producing overpressure when compared to the spherical geometry. Depth was found to be a factor in the magnitude of pressure captured in the simulation time histories.

Both types of initiators bring their own safety concerns. While high explosives are more routinely used, they still pose undesirable characteristics such as high sensitivity, volatility, hygroscopicity and toxicity. Implosion events on the other hand suffer from the unpredictability of the process itself. Though not a direct focus of this study, practical engineering issues such as size, weight and fabrication of the initiators, transportation and handling, and their deployment, exist in the case of implosion initiation devices. The details of these features are important in accurately capturing the method of failure initiation (crack, spark, etc.) in the implodable volume casing ,which varies and presents potential challenges in modeling the result within the finite element method code and the physical article as well

The study conducted here continues to build upon the knowledge of implosion. It should help better inform decision makers in the planning and selection of potential deep-sea initiator designs for neutralization of seabed targets.

NPS NRP Executive Summary

Hydrocode Analysis of Seabed Effector Initiation Options

Report Date: 11/01/19 Project Number (IREF ID): NPS-19-N079-A

Naval Postgraduate School, Graduate School of Engineering and Applied Sciences

Recommendations for Further Research

Additional research is recommended in the directional focusing of implosion-initiated shock fronts for determination of potential in generating increased pressure loading on representative targets operating in the deep-sea environment. Related to this is the concept of implosion-induced water-jetting as a means of potential damage mechanisms for seabed effectors.

Acronyms

Underwater Explosion UNDEX

Commander, Submarine Force, U.S. Pacific Fleet COMSUBPAC