The Challenge for Improved Ocean Vehicles--
A David Taylor Naval Ship R&D Center Perspective

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Developing vehicles for operation on and under the ocean surface to serve in a hostile environment (both natural and man made) is the primary mission of the David Taylor Naval Ship R&D Center (DTNSRDC).

The broad areas encompassed range from developing new hulls more stable in seaways, materials that better tolerate the effects of the ocean, or new naval systems that improve fleet performance.

The Center is a vertically integrated organization that provides technological expertise and unique Free World facilities to solve ocean engineering problems. Vehicle development, energy efficient ships, ocean wave prediction, anti-fouling materials and other marine technology programs at the Center advance our capability to ply the seaways more efficiently and effectively.

In the last decade, deep submergence technology has focused on electric drive, new buoyancy materials, variable ballast systems and other component development; as well as fluids, lubricants, hydraulic systems and electrical insulation to be used to depths of 20,000 feet. These systems will be demonstrated on SEA CLIFF.

We are investigating thick laminate composite materials for ship hulls and piping systems, as well as truss-spaced core materials. These materials will reduce topside structure weight and improve ship stability.

Our still unique, time tested, deep submergence tanks and hydrodynamic basins play key roles in the development of vehicle technology--like ALVIN and SWATH. Using them, we conduct research on drag reduction and propulsion efficiency.

This paper presents a brief overview of Center accomplishments and relevant current efforts that demonstrate its capability to go "From Research to Reality," a theme focused on new challenges in ocean engineering for the coming era.

INTRODUCTION

Developing vehicles for operation on and under the ocean surface is the primary mission of the David Taylor Naval Ship R&D Center (DTNSRDC). The Center is a vertically integrated organization that provides technological expertise and facilities unique in the free world.

The Center began in 1896, when Congress mandated the establishment of a model tank to investigate hull forms of ships. Today, we operate two major laboratory sites at Carderock and Annapolis, Maryland, as well as five detachments around the nation. We conduct research and development in the technology areas of hydrodynamics, aerodynamics, structures, acoustics, machinery, materials and logistics support.

The Center business is vehicle development. Our product is technology for submarines, conventional displacement monohull surface ships and advanced ships. These include hydrofoils, surface effect ships, air cushion vehicles and Small Waterplane Area Twin Hull (SWATH) ships. We also continue to solve ship design problems for Navy, the Maritime Administration, and private sponsors.

FACILITIES

Many Center facilities are unique national resources. They allow us to develop and evaluate R&D concepts and prototypes prior to commitment for full scale sea trials and final assessment. The hydrodynamic basins, for which the Center is perhaps best known, form the backbone of our ocean technology capabilities. Measuring nearly a kilometer in length, the David Taylor Model Basin contains two deep water basins; a shallow water basin, turning basin and high speed basin. Pneumatic wave makers provide waves of uniform length and height. Comprehensive programs on advanced hull forms, propulsors, stabilizers, rudders and new design components support both government and private programs.

The Center's 36-inch water tunnel, which has operated for more than twenty years, is a vital part of our propulsion investigations. Using the tunnel, we study noise, vibration and propulsor cavitation. However, this small chamber does not allow evaluation of interaction effects on propeller, rudder, hull, appendage or wake. Before the end of this decade, the Center will install a large cavitation channel (Figure 1) (LCC), with an experimental section of 3m x 3m x 12m and a water velocity to 30 kts. The channel will be housed in a ship and marine

LARGE CAVITATION CHANNEL

Figure 1

laboratory containing close to 70,000 square feet of space. Although the test medium is water, the LCC resembles a wind tunnel. In it, we will be able to accommodate models of entire hulls with their propellers. The LCC will satisfy stringent requirements for hydrodynamic and acoustic performance which the Navy and merchant fleet now demand. The capabilities of this new facility are not duplicated anywhere in the free world.

The Center's Deep Ocean Simulation Facility, installed in 1968, provides test conditions duplicating pressures and temperatures in the deepest parts of the ocean. Only recently, variable ballast pumps and electric motor systems received qualification testing in the tank before subjection to full scale evaluation and use aboard the deep submergence vehicle, SEA CLIFF. In addition, PISCES IV, the submersible, was recently pressure tested for Canada's Department of Fisheries and Oceans. This manned test was conducted in the large pressure vessel; depths to 6600 feet were simulated. This unique ocean pressure laboratory provides Navy and industry with a way to evaluate a variety of deep submergence vehicles and vehicle components.

PROGRAMS

The Center has many programs in Ocean Engineering. Examples of our work and accomplishments are found in materials technology, improved performance systems like electric drive, numerical methods to optimize design technology and environmental work such as ocean wave prediction.

In the last decade, deep ocean technology has focused on electric drive, new buoyancy materials, variable ballast systems and other components. This has resulted not only in expanding these technologies but also that of fluids, lubricants, hydraulic systems and electrical insulation for use to depths of 20,000 feet. The systems and component technology documented in Center handbooks will be demonstrated aboard SEA CLIFF. We now are examining the reliability and extended endurance of machinery; the size and weight reduction of components; advanced power systems like fuel cells for the Deep Submergence Rescue Vehicle (DSRV); and power and electrical circuitry for control systems.

Materials research in cast titanium are allowing impellers, valve balls, and pump bodies that are light weight and corrosion and erosion resistant. These can be used on board ship to provide long term, maintenance free performance. Titanium valve balls have successfully been used in service for more than 10 years. A recently developed cast titanium auxiliary sea water pump demonstrated more than 28,000 hours of successful in-service operation. The housing, (Figure 2) represents an important advancement that now is being applied to the Navy standard fire-pump for fleet and potential commercial use.

Further, Center development of a new titanium alloy (Ti-3Al-2.5V) will provide better piping material to reduce weight and increase seawater flow rates. Inconel 625, which has advantages similar to titanium alloys, will be used in high pressure sea water piping systems on advanced naval vessels. In addition, this material is readily weldable to steel.

We are promoting the use of high strength, low alloy (HSLA) steels to replace HY-80 steel for surface ships and have a significant development program underway to make this replacement feasible: HSLA steel is significantly lower in cost. We also are investigating its weldability and the technology of thick section fabrication.

Figure 2 - Titanium Casting, ASW Pump Housing

Composite material programs have been part of our research and development work for more than twenty years. Programs directed toward hull structure and components for submersibles, submarines, surface ships and hydrofoils have created an invaluable technology base. This base now is applied to topside structures for surface ships -- such as deck house panels; non-pressure hull submarine structures, like control surfaces and air flasks; and hulls for unmanned deep submersibles. We are planning as well to develop a graphite reinforced epoxy hull for manned deep submersibles.

On another front, the increasing need to rapidly improve vehicle design at reasonable cost calls for improved performance prediction. The Center is an international leader in advanced computer technology, and develops programs so that new ship concepts can be evaluated quickly, putting promising ideas to sea without delay. Examples are the computation of wake flow behind a transom stern; and the stress pattern prediction of a surface ship propeller blade.

Finally, something must be said of our work in antifouling paints. In cooperation with industry, we have developed a family of organometallic polymers (OMP) antifouling agents. These paints offer longer effectiveness and lower long term costs than coatings now used. Two such candidates now are under evaluation on board ship. Industry is increasing production; our present target is batches of 100,000 lbs. We expect these antifouling OMP paints to be available commercially within the next five years. This program, which began at the Center in 1971, should result in significant savings in ship fuel costs.

CONCLUSION

In conclusion, the David Taylor Naval Ship R&D Center continues to play an active role in ocean engineering technology, spearheading many innovative concepts. As we develop these concepts, we take another step toward realizing efficient and effective ocean vehicles for the seaways, exploring the under-sea environment or harnessing ocean resources. This is the Center's challenge. To meet it, our management strategy is one of involvement. From laboratory investigations to at sea testing of hardware -- we are there -- a philosophy summarized in our motto -- "From Research to Reality".

Figure 3 - Axisymmetric Underwater Body