

Propulsor Blade Advanced Composite Materials

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PROBLEM STATEMENT

There is growing interest in the U.S. Navy marine community in the use of composite materials for propulsor blade applications. Composite materials offer substantial benefit potential over traditionally used metals (e.g., nickel-aluminum-bronze and stainless steel) that include very good specific properties, high corrosion resistance and design tailor-ability. These attributes can translate into a propulsion system that is substantially lighter, more cost-efficient and performance optimized in comparison to equivalent metal-based systems. However, substantial uncertainty remains regarding the performance of composite materials in an underwater environment including their performance in high-cycle fatigue, cavitation erosion and high-rate impact environments. Current state-of-the-art composites have been shown to possess greatly inferior cavitation erosion performance than metals. The current program is focused on developing new composite materials that will deliver the added benefits of composites to propulsor blades while maintaining high resistance to cavitation erosion.

WHO CAN BENEFIT?

In addition to propulsor blade applications, many other U.S. Navy platforms can benefit from our advanced composite materials. These include other marine applications such as composite hulls, control surfaces, ballast tanks, sails and masts. Furthermore, there are numerous additional applications for the defense community at large that can benefit from these materials including aeronautical applications for which rain erosion resistance, abrasion resistance, and impact resistance are critical (e.g.: helicopter rotors, etc). Many currently deployed platforms and structures in Iraq and Afghanistan suffer from inadequate resistance to sand erosion and may be supplemented with our composite materials for improved durability.

BASELINE TECHNOLOGY

Metal materials such as nickel-aluminum-bronze (NAB) alloy are currently used by the Navy for propulsors. The current materials perform reasonably well in the propulsor environment including high-cycle fatigue, cavitation erosion and high-rate impact environments. However, their specific mechanical properties, corrosion resistance, design tailor-ability and manufacturability are lacking relative to fiber-reinforced composites.

TECHNOLOGY DESCRIPTION

CTD has developed advanced composite materials having performance that is optimized for the underwater propulsor environment. More specifically, CTD has developed and tested composite materials that possess substantially higher cavitation erosion resistance in comparison to current commercially available materials. This has been done in partnership with the University of Maine (UMaine) and Dynaflo, Inc. (Dynaflo) to screen candidate materials for cavitation erosion resistance and identify key material parameters most affecting their cavitation erosion resistance. CTD is also collaborating with Alion Science and Technology's Engineering Technology Center (Alion) to identify methods for incorporating highly cavitation erosion resistant composite materials into a propeller blade composite construction to meet the high durability and hydrodynamic performance requirements of U.S. Navy propellers. A summary of these efforts is shown in Figure 1.

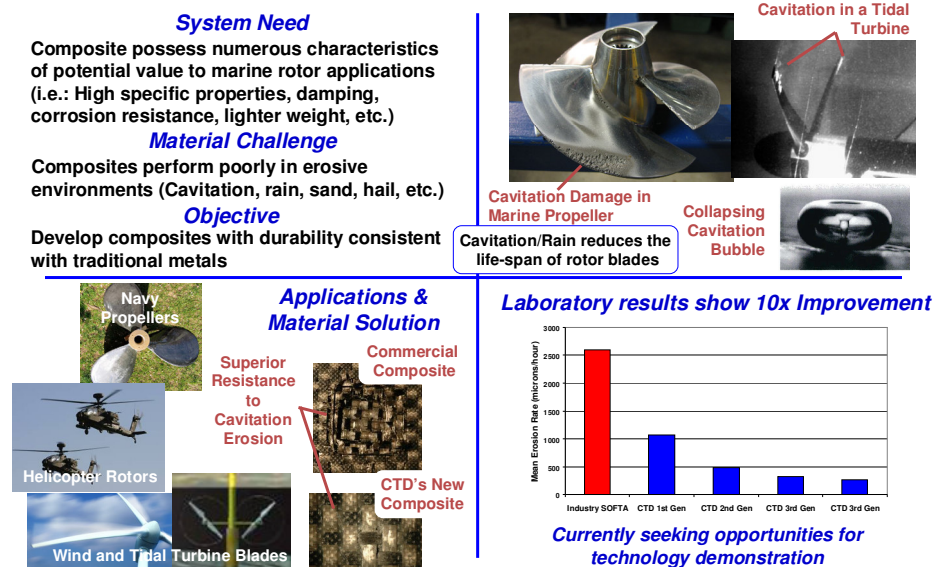


Figure 1. Summary of CTD's erosion resistant composite development.

The vision for incorporating the present technology in next-generation composite propulsors is based on the concept of tailoring construction and material selection in specific areas of the propulsor to optimize performance in that area. Since it is

assumed that no single material can be optimized for all performance requirements associated with naval marine propellers, different requirements are used to drive the blade design for different blade areas. A schematic of this conceptual approach is provided in Figure 2 illustrating potential key areas where material selection and composite construction are optimized. In particular, cavitation-erosion resistance would be optimized in the blade's tip and outer leading and trailing edges. Exposed blunt edges would be optimized for impact, the center section would be optimized for fatigue performance and the blade's root would be optimized for high stiffness and shock resistance. The current program is focused on developing a variety of materials that can be used in a graded or tailored manner corresponding to the different blade areas of concern. Composite materials are ideally suited to this approach as both properties and constituent materials can easily be varied during component design and manufacturing. Ultimately, it is believed that this approach is necessary to develop composite propellers with improved performance over traditional metal (e.g., nickel-aluminum-bronze) blades.

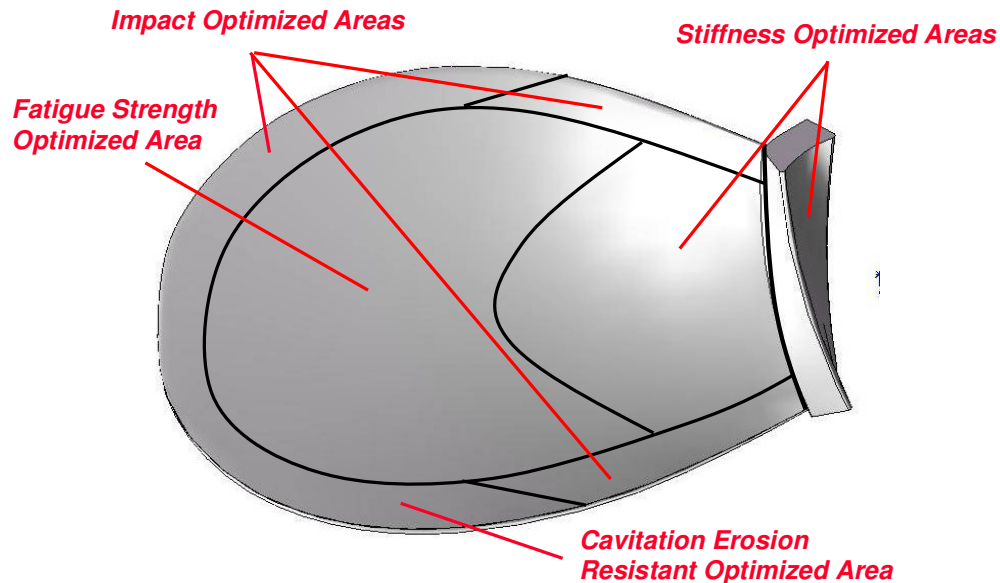


Figure 2. Vision for optimized composite propulsor blade via functionally graded construction.

CURRENT STATE OF DEVELOPMENT

Roughly an order of magnitude improvement in cavitation erosion resistance has been demonstrated over existing state of the art composite materials using both the cavitating jets test protocol and the vibratory induction cavitation test protocol. As shown in the title image, manufacturing feasibility using the new materials has been demonstrated. Mechanical testing has been done on the new materials showing that they easily meet a set of minimum material property requirements derived by the U. S. Navy. CTD is currently fabricating a set of composite blades with cavitation resistant materials for testing in a water tunnel at

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NSWC- Carderock Division. The current significant developmental need is to demonstrate the materials in application and to increase manufacturing capabilities for product commercialization.

ABOUT THE COMPANY

Composite Technology Development, Inc. (CTD) is a small company with global reach, and the realization of a vision to deliver innovation to a wide range of products through the integration of novel materials and insightful engineering. CTD is a company where product innovation is a natural byproduct of an open environment where talented scientists, engineers, and technicians collaborate across technical disciplines, and with their corporate customers, to discover non-obvious yet simple solutions to challenging product-design problems. CTD has an international list of clients and customers in markets including: alternative energy; satellite systems; sports and rehabilitation; and aviation and marine systems. Over our 20-year history, we have created a wide-ranging portfolio of materials and engineering intellectual property, and have positioned the company for continued growth and future successes with an ever-broadening business base.