A Very Lightweight Composite Hatch

KAZAK Composites Inc.
32 Cummings Park
Woburn, MA 01801

Contact: Dr. Jerry Fanucci; Dr. Hal Tugal
Telephone: (781) 932 – 5667 x100; x114
Fax: (781) 932 – 5673
E-Mail: jfanucci@kazakcomposites.com
htugal@kazakcomposites.com
Website: www.kazakcomposites.com

Command: NAVSEA
Topic: N01-060

PROBLEM STATEMENT

DDG-51 hatches and scuttles (Figure 1) are traditionally made from steel. During many years of marine service, steel has proven to be relatively inexpensive to buy, demonstrated good resistance to damage from routine operational impacts, provided inherent EMI and EMP shielding, and performed well in fire tests such as MIL-STD-2031.

Steel hatches and scuttles have several drawbacks, however. Life-cycle cost is high because considerable routine maintenance is required. Safety is also an issue: the steel hatch is heavy and requires either 2 or 3 people to open creating issues particularly in rough weather and other difficult circumstances. Changing Navy crew demographics, especially with the increasing number of women serving onboard ships, has elevated the importance of hatch-and-scuttle weight reduction. Navy has now placed a high priority on hatch weight reduction.

The composite hatch under development by KAZAK Composites is a replacement for the current operational 30 x 60-inch steel hatch-and-scuttle system used on the DDG 51. The KAZAK Composite Hatch is cost competitive with the current metal hatch system and can be opened by 1 person eliminating the need for a separate scuttle. Also the new composite hatch will meet the other important requirements for shipboard service including EMI shielding and fire performance, and reduce life-cycle cost by decreasing routine maintenance needs associated with corrosion.
WHO CAN BENEFIT?

The KAZAKore composite technology developed for the DDG 51 hatch program can be applied to any steel doors on naval ship platforms such as LPD17, LHA(R), CV, CVN and CG47. Any steel garage doors at military warehouses, Army truck transport freight systems carrying hazardous material in metal containers, and Army and Corps of Engineers portable structures such as shelters susceptible to fire can benefit from KAZAKore composite technology.

BASELINE TECHNOLOGY

Current steel hatches and scuttles are heavy, difficult to open, and the life-cycle cost is high because considerable routine maintenance is required. These problems can be eliminated with the KAZAK Composite Hatch. Table 1 compares the baseline steel hatch and scuttle with the KAZAK Composite Hatch. In the current composite hatch design, the moving hatch is estimated to be approximately 60 to 80 pounds compared to 240 pounds for the baseline steel hatch. Since 1 person can open the composite hatch, no scuttle is required. The composite hatch is low maintenance and will reduce life cycle costs.

Table 1: Comparing KAZAK Composite Hatch to All Steel Baseline

<table>
<thead>
<tr>
<th>Specification</th>
<th>Baseline</th>
<th>KAZAK Composite Hatch</th>
</tr>
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<tbody>
<tr>
<td>Design</td>
<td>Hatch-and-scuttle</td>
<td>Hatch only</td>
</tr>
<tr>
<td>Composition</td>
<td>All steel</td>
<td>Hybrid Composite</td>
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<td></td>
<td></td>
<td>Minimal metal used at hatch perimeter to reduce wear.</td>
</tr>
<tr>
<td>Door Weight</td>
<td>150 lb (30 x 60-inch); weight</td>
<td>60 – 80 lb (30 x 60-inch)</td>
</tr>
<tr>
<td></td>
<td>with the scuttle is 240 pounds.</td>
<td></td>
</tr>
<tr>
<td>Operation</td>
<td>2 – 3 People</td>
<td>1 Person</td>
</tr>
<tr>
<td>Personnel Safety</td>
<td>Opening is impeded due to cor-</td>
<td>Increases safety by resisting corrosion.</td>
</tr>
<tr>
<td></td>
<td>rossion</td>
<td></td>
</tr>
<tr>
<td>Fire Resistance</td>
<td>High thermal conduction during</td>
<td>Improved fire, smoke, and toxicity performance via low</td>
</tr>
<tr>
<td></td>
<td>fire.</td>
<td>thermal conduction relative to steel and other polymers.</td>
</tr>
<tr>
<td>EMI, hydrostatic, shock &amp;</td>
<td>Meets requirements</td>
<td>Meets requirements</td>
</tr>
<tr>
<td>mechanical properties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>Periodic painting of corroded</td>
<td>No painting required. Hatch is corrosion, damage, and wear</td>
</tr>
<tr>
<td></td>
<td>and/or damaged hatch.</td>
<td>resistant.</td>
</tr>
<tr>
<td>Life-cycle cost</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Unit Cost</td>
<td>$2,500 - $5,000</td>
<td>Approximately Same</td>
</tr>
</tbody>
</table>
TECHNOLOGY DESCRIPTION

KAZAK Composites’ approach to the design of a new composite hatch to replace the current steel hatch-and-scuttle combination has four aspects; the first is the hatch composite panel, the second is the hatch mechanism, the third is the hatch frame / panel interface, and the fourth is the fire seal performance.

1. Hatch Composite Panel: KAZAK Composites has developed and performed tests on a composite panel structure, called KAZAKore. The hatch-and-scuttle is now replaced by a KAZAKore panel with improved strength, stiffness and reliability at reduced weight, and provides electromagnetic insulation (EMI) shielding.

2. Hatch Mechanism: The operating hardware and mechanisms are removed from the moving portion of the hatch and placed underneath the deck. At the same time a method is designed for continuously engaging almost the entire hatch panel perimeter. The hatch mechanism provides tight seal under mechanical and thermal loads and allows low effort operation of latch release handle. Additionally, a continuous dogging mechanism improves flame mitigation in a fire situation. The latching design is shown in Figures 2, 3 and 4.

   In the design, a rotating cam mechanism encompasses the perimeter of the hatch opening and is interrupted only at the corners to accommodate universal joints (Figure 3 and 4). A lever located at either side of the coaming wall operates the latch and as intended, the latch can be engaged and disengaged in a single 90-degree rotation. When the lever is rotated, the gearbox at the lever base acts and transmits torque to the camshafts located at right angles to the unit. Torque is transmitted along the shafts and through the universal joints. In latching, the lever actuates the cams to rotate against the cam seat that runs the perimeter of the door panel frame (Figure 3). Rotational energy generated by the camshaft is translated into a linear force as the cam seats against the frame. This causes the panel gasket to press against the coaming edge and generate the necessary sealing pre-load. The lever is actuated until the pawl mechanism in the gearbox captures the lever positions. Figure 4a illustrates the lever and gearbox arrangement used to actuate the latch. The lever shaft runs through both faces of the coaming. A detailed view of the cam shaft universal joint is shown in Figure 4b.

3. Hatch Frame / Panel Interface: The KAZAKore composite panel is inserted into a fully encompassing frame structure that carries the latching and bearing loads. The design optimizes the joint between the frame and panel to meet all required boundary conditions such as those extreme thermal loads generated in a fire or environmental conditions such as humidity. Currently KAZAK Composites is investigating means to integrate the panel and frame by inserting wear resistant and bearing surface materials.

4. Hatch Seal: The current weakness shared by all past, present, and proposed hatch designs is the hatch seal. No method exists to prevent fire from creating a leak path through the rubber seal material which burns-out at elevated flame temperatures. KAZAK is currently studying intumescent coatings that will expand and fill the burned-out seal void, preventing a leak path for hot gases and flame. Additionally, KAZAK is exploring braided ceramic / rubber thermal seal technology aimed at reducing the void left by the burned-out seal.
The price associated with the baseline technology is approximately same as the all steel hatch-and-scuttle system.

Figure 3 – Continuous latch encompasses opening perimeter

Figure 4 – Latching mechanism details; (a) Latch gearbox, (b) Cam shaft universal joint

CURRENT STATE OF DEVELOPMENT

Ingalls Shipbuilding has demonstrated the general viability of the composite hatch-and-scuttle concept by using a variation of the vacuum-assisted resin transfer molding process (VARTM) to make a glass fiber reinforced composite prototype. KAZAK Composites has developed and performed tests on a composite panel structure, called KAZAKore, that strongly indicates that it will pass the MIL-STD 2031 for interior application of composites and UL-1709 flame resistance tests.

In order to verify the proposed hatch design, KAZAK Composites plans to build full-scale mechanism, coordinate design details with Bath Iron Works personnel, and fabricate full-scale hatch mechanism prototype for sealing / ergonomic tests.
After this sub-scale testing, full size hatch test rig will be used to perform fire, EMI, hydrostatic, shock and mechanical testing on the prototype hatch.

In September 2004, the end of Phase II, a prototype KAZAK Composite Hatch will be at Technology Readiness Level 6 and available for sea-trials on a DDG51-class ship.

REFERENCES

The following individuals can provide information on the KAZAK Composite Hatch:

- Robert Redfern, Code 9782, Naval Surface Warfare Center, Carderock Division, Ship Systems Engineering Station (NSWCCD-SSES), 5001 South Broad Street, Philadelphia, PA 19112-1403; robert.redfern@navy.mil; (215) 897-1082 (Present TPOC and SBIR Program Manager)
- Frank Rucky, Division Sponsor (SBIR), PMS 400, 2531 Jefferson Davis Highway, Arlington, VA 22202, (703) 418-8216.
- Anthony Nickens, Sponsor (SBIR), Code: SEA 05R1, 1333 Isaac Hull Ave., S.E., Washington, DC 20376, (202) 781-3749.

“Conventional and Revolutionary Material Solutions for Composite Hatches and Scuttles” Phase I Final Report, Date Submitted: January 17, 2002

US Patent Application #: 10/357,735. Application date: 02/04/03. Title: Hatch or Door System for Securing and Sealing Openings in Marine Vessels.

TECHNOLOGY AVAILABLE

The very lightweight KAZAK Composite Hatch will be tested and ready for commercial delivery beginning in the fall of 2006.

ABOUT THE COMPANY

KAZAK Composites Inc. is a Massachusetts based company that designs, develops, manufactures, and markets high performance composite structures. By integrating innovative engineering design and proprietary low cost manufacturing processes, with specialization in large and unusual pultrusion processing, the Company provides superior value products for the aerospace, military, and commercial markets.

A privately held company, KAZAK Composites Inc. was established in 1992 and has grown to nearly 25 employees, most of whom are degreed engineers and scientists. Company’s expertise is in composite materials, mechanical & structural design analyses. The Company is headquartered in Woburn, Massachusetts and maintains manufacturing facility in Yemassee, South Caro-
At Yemassee the world’s largest pultrusion equipment is located, capable of pultruding 10 feet wide and up to 6 inches thick composite materials continuously.

The founder, Dr. Jerome Fanucci, has over 20 years experience in the military composites industry. Before starting KAZAK Composites Inc., Dr. Fanucci held positions at several aerospace and composite manufacturing facilities, where his efforts included design of composite nuclear hardened structures and verification of composite structure for the B2 bomber. He was manager of composite shelter development programs at the US Army Natick RD&E Center.