Research seeks lighter, more versatile structures

by Harry H. Hilton

The Air Force Institute of Technology is working on a lighter-than-air vehicle and has considered structures such as a icosahedron and a celestial sphere. Findings are still being reviewed, but material properties and mistuned rotors are major issues. The study is developing advanced experimental and analytical approaches for the accurate assessment of turbine engine component life. Additional work will help quantify uncertainty propagation from the initial modeling and computational predictions to the experimental application and results.

NASA Langley Research Center is acquiring a state-of-the-art composites fabrication environment to support its research and technology development mission. This overall system is called ISAAC, for Integrated Structural Assembly of Advanced Composites. ISAAC’s initial operational capability is a commercial robotic automated fiber placement system from Electroimpact Inc. with a multiple-degrees-of-freedom commercial robot platform, a tool changer mechanism and a specialized automated fiber placement end effector. Developments included advanced composite materials, structures, fabrication processes and technology.

The University of Pisa’s Civil and Industrial Engineering Department is conducting a research project, called IDINTOS, to design and manufacture an amphibious light aircraft with a PrandtlPlane box-wing configuration for small industries. Projects concluded with construction of a prototype with main and front retractable landing gears, tip wings of the PrandtlPlane configuration, fin and rudder, hull and two shrouded propellers.

NASA Johnson Space Center’s Inflatable Structures Team performed an inflatable pressure vessel creep burst test. The 7.5-foot-diameter, 10-foot-long woven Vectran article was designed for 36 pounds per square inch gauge and tested to failure to help understand time-dependent, end-of-life properties. The structure was pressurized to an internal pressure of 145 psig (74 percent static burst pressure) until the structural restraint layer burst. In addition to creep performance, the results will be used to study the structure’s loading and dynamic behavior.

Arizona State University’s Adaptive Intelligent Materials & Systems Center and Aerojet Rocketdyne are developing stochastic multiphysics, multiscale modeling for improved analysis of carbon fiber reinforced ceramic matrix composites for advanced rocket propulsion applications. The effort focuses on accurate and efficient material characterization through serial sectioning and 3-D model reconstruction to study progressive damage models. Weave and tow architectures contain voids due to manufacturing, which are key model features.

The Air Force Research Laboratory and Lockheed Martin Aeronautics led efforts to benchmark composite progressive failure analysis tools for static loading conditions. AFRL’s structures lab measured basic lamina properties of common graphite/epoxy and delivered them to 10 analysis teams for model calibration. After calibration, each team predicted stiffness, strength and damage characteristics of notched and open-hole tension and compression coupon tests of three different layups. The results varied with some predictions falling within 1 percent of the experimental mean while others were off by more than 25 percent.

An 18-foot-diameter tank built by Boeing was delivered to NASA Marshall Space Flight Center. The tank was then filled with liquid hydrogen at simulated launch condition pressures. This is the first time a tank of this size has been proven to sustain the thermal environment of liquid hydrogen at these pressures. The design is more structurally efficient then its predecessors and represents significant technology achievements for NASA, Boeing and industry. The technology could prove beneficial to the U.S. launch industry and other industries that want to replace heavy metal components with lightweight composites.

SpaceX attached landing gear onto the Falcon 9 rocket that will launch the company’s unmanned Dragon cargo capsule toward the International Space Station. This marks another step in SpaceX’s quest to develop a fully reusable launch system. The launch vehicle will continue to make ocean landings and will not attempt a surface landing until precision control from hypersonic through subsonic regimes is achieved.

Purdue University is developing an accelerated certification process for aerospace composites in an effort to reduce costly physical testing requirements. The slightest design or material change increases costs and suppliers often publish material properties that become the basic information required to run virtual simulations, but this information is insufficient, requiring additional performance parameters.