

This type of buffeting has reduced the airframe fatigue lives and the system reliabilities of several legacy aircraft. This situation has been brought on largely because tail buffet loads have generally been ignored in the design of twin-tailed fighter airplanes. There are several reasons for this oversight: Fundamentally, tail buffet loads have not been identified as a major concern in designing fighter airframes. More practical reasons are that, until recently, (1) there was a lack of quantitative data on buffet forces; and (2) no readily available and cohesive analysis method could be used to predict buffet

loads during the design of fighter airplanes.

Now, there exists a new analysis capability for predicting buffet loads during the earliest design phase of a fighter-aircraft program. In effect, buffet pressures are applied to mathematical models in the framework of a finite-element code, complete with aeroelastic properties and working knowledge of the spatiality of the buffet pressures for all flight conditions. The results of analysis performed by use of this capability illustrate those vibratory modes of a tail fin that are most likely to be affected by buffet loads. Hence, the results help in identifying

the flight conditions during which to expect problems. Using this capability, an aircraft designer can make adjustments to the airframe and possibly the aerodynamics, leading to a more robust design.

This capability has been utilized in the design of the Joint Strike Fighter, leading to better understanding of buffet loads and to total redesign of the airframe to avoid fatigue-life issues.

This work was done by Robert W. Moses and Anthony S. Pototzky of Langley Research Center. For further information, contact the Intellectual Property Team at (757) 864-3521. LAR-16515

Water-filled containers are stacked like bricks.

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Water-filled containers are used as building blocks in a new generation of containment systems for testing high-speed flywheels. Such containment systems are needed to ensure safety by trapping high-speed debris in the event of centrifugal breakup or bearing failure. Traditional containment systems for testing flywheels consist mainly of thick steel rings. While steel rings are effective for protecting against fragments from conventional and relatively simple metal flywheels, they are also expensive. Moreover, it is difficult and expensive to configure steel-ring containment systems for testing of advanced flywheel systems that can include flywheels made of composite materials, counter-rotating flywheels, and/or multiple flywheels rotating about different axes. In contrast, one can quickly, easily, and inexpensively stack water-filled containers like bricks to build walls, (and, if needed, floors, and ceilings) of sufficient thickness to trap debris traveling in any possible direction at the maximum possible kinetic energy that could be encountered in testing a given flywheel system.

Water is remarkably effective in decel-

erating high-speed debris: In an analysis performed in 1998, it was found that for a fragment that has a characteristic dimension L and an initial kinetic energy E_0 , the kinetic energy E after traveling a distance d through water is approximated by $E = E_0 e^{-d/L}$. For typical fragment sizes and speeds expected to be encountered in tests of advanced flywheel systems, this equation leads to the expectation that a wall of water only 0.6 m thick would suffice to dissipate practically all the kinetic energy.

The effectiveness of this approach to shielding against high-speed debris was demonstrated in a series of tests, including one in which a bullet was fired into a stack of two cubic cardboard boxes, 0.28 m on each side, containing water-filled bladders (see figure). The bullet had a mass of 9.7 g and an initial speed of 790 m/s. Upon impact, the first container was split, the water in the container was widely dispersed, and the bullet was deformed. The bullet did not reach the second container. In other words, the bullet was stopped by less than 0.28 m of water. Limited composite fragment testing was also performed in the Ballistics Impact



A Bullet Was Fired from the left toward two cubic water-filled containers. The bullet was stopped by the first container.

Laboratory at Glenn Research Center, which demonstrated the ability to stop a $2.5 \times 2.5 \times 1.0$ cm fragment with a velocity of approximately 730 m/s within 30.5 cm of water.

This work was done by Larry Trase and Dennis Thompson of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17608-1.