Keeping Vintage Planes in the Air

Raetech Corporation

Aerospace

U.S.A.

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ANSYS® Workbench
ANSYS® Mechanical™

Overview

The T-34 Mentor is a two-seater, single-propeller plane manufactured primarily in the 1950s for training military pilots. The U.S. Air Force and Navy found the aircraft excellent for the intermediate phase of training pilots before going to jet aircraft. In 1960, the military began implementing jet trainers, but the T-34 plane remains in use for pilot training as well as aerobatics and aerial demonstrations. Although the T-34 established a good safety record over decades of use, the Federal Aviation Administration (FAA) grounded the entire fleet of about 500 aircraft after a catastrophic in-flight failure stemming from metal fatigue in the lower spar carry-through structure connecting the wing to the fuselage.

The T-34 Owners Association and General Aviation Modifications, Inc. (GAMI) subsequently called upon engineering consulting firm Raetech Corporation to help determine the cause of the airframe failure and find ways to avoid the problem. In studying the airframe, Raetech drew upon its extensive experience primarily in the transportation and motorsports industries. The company uses advanced analysis techniques in providing solutions to a wide range of problems at every stage of the product lifecycle, from concept generation and design through testing and failure analysis. Since its inception in the early 1980s, Raetech has developed complete race cars and motorsports parts assemblies as well as powertrain and chassis components for major auto manufacturers.

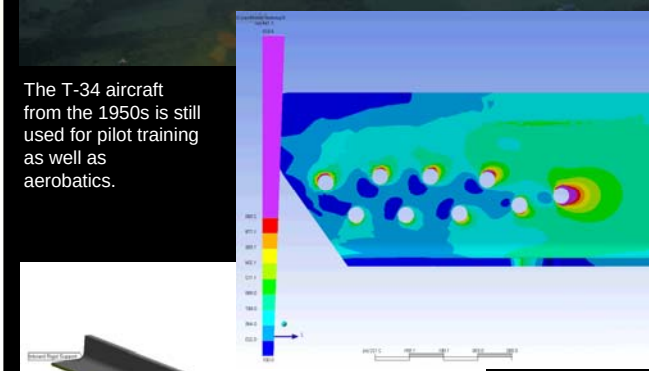
Testimonial

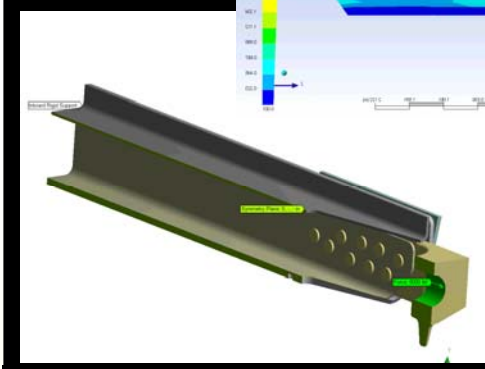
“ANSYS Workbench surface-to-surface contact element technology enabled us to efficiently and accurately model the numerous parts that touch one another in the T-34 aircraft lower spar carry-through structure. Without this capability, the simulation that was critical in getting the planes safely back in the air would have been much more time consuming, error-prone and difficult to perform. The ability to perform stress analysis and fatigue life prediction within the same program also was highly useful in providing insight into the overall problem.”

Kevin Kwiatkowski
Senior Structural Engineer
Raetech Corporation

Photo Courtesy of American Aerobatics

The T-34 aircraft from the 1950s is still used for pilot training as well as aerobatics.





Raetech used ANSYS Workbench to analyze the riveted spar assembly of a T-34 aircraft under a range of loading conditions (lower left). The simulation accurately determined stresses and fatigue life (upper right), proving an adequate design for the aircraft when flown within the prescribed limits.

Challenge

Initial assessment of the failure showed its roots in fatigue of the 2,024 aluminum channels that form the lower spar carry-through structure. The failure began at the hole for the furthest inboard rivet. Conducting physical tests on the actual hardware would have been prohibitively expensive and time-consuming to perform, given budget limitations and deadline constraints. But representing the structural assembly for simulation with conventional finite element analysis (FEA) would have been difficult. Typically, parts that touch one another in such an assembly must be manually identified and individually meshed to avoid element discontinuities. This is a tedious process, especially in projects such as this in which multiple analyses must be run for different fatigue loading cycles and rivet clamping conditions.

Solution

Raetech met the challenge with contact element technology in ANSYS Workbench to determine the stress field surrounding the problematic rivet hole. Parts were first modeled in SolidWorks and the geometry imported into ANSYS Workbench, which automatically detects surface-to-surface contacts and allows for components’ dissimilar meshes. Several models were created and analyzed to simulate possible loading conditions. Full clamp loading was analyzed using bonded contacts with faces split in the appropriate locations on all touching surfaces under the rivet heads. Loss of clamp was analyzed using frictionless contact on touching surfaces in the riveted structure when loads are transferred through the rivet shanks. Using these stress fields, multiple fatigue analyses were performed in ANSYS Workbench using the airframe’s intended loads.

Benefits

The FAA used bonded contact stress field results to approve the positioning of strain gages in airframe tests by GAMI to measure in-flight stress levels. Results from the zero clamp-load analysis were used to determine principal stress near the problematic rivet hole and study crack propagation and critical crack size. Based on the data, the FAA concluded that the failure was due to the aircraft being flown beyond its design limits. The particular plane had a history of performing mock aerial combat maneuvers. The agency allowed the T-34 fleet back into the air with better-defined load limits and crack inspections. As a result, eddy current testing is performed to detect cracks before they reach critical size, and lower spar carry-through inspections are now a required part of the T-34 maintenance schedule.