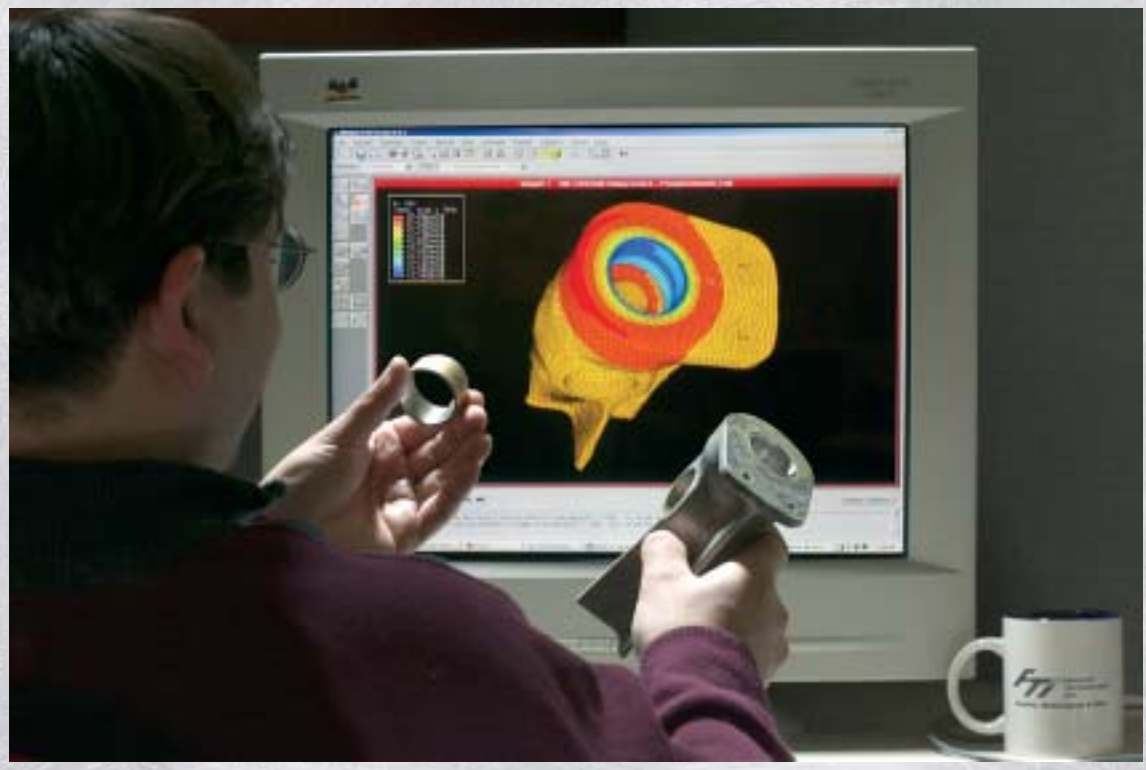
Focus on FTI®
FATIGUE TECHNOLOGY INC.
April 2005

FTI and Engineering Analysis



In today's world of aircraft manufacturing and maintenance, there is an ever-increasing demand to design structures that will fly longer and weigh less than ever before. In order to accomplish this goal (in a budget-tight environment) engineers rely on computer simulations and modeling to supplement or in some cases replace testing.

Every major manufacturer utilizes Finite Element Analysis (FEA) in their design and research and FTI is no exception. There is a reason why we say we are the "world leaders in cold expansion technology" and FEA analysis is an integral part of our capabilities.

FTI is committed to providing our customers the most accurate information about the benefits of cold expansion technology. We are determined to provide the most up-to-date research so our customers have the ability to:

- Save structural weight
- Reduce inspection intervals
- Increase structural fatigue and durability life
- Decrease manufacturing flow-time and costs
- Simplify assembly design

We have spent years studying and testing the cold expansion process so we can push this technology forward with new products and solutions.

Our recent analyses and research have given us greater insight into our products and technology and have uncovered some interesting results. Some of our discoveries include:

- A true understanding of the stresses and strains on the structure due to the cold expansion process.
- Realization that the benefits of cold expansion remained, even when done with oversized or out-of-round starting holes in the parent material.
- When designing or re-designing a part to incorporate cold expansion, the part's geometry needs to be taken into account for optimal fatigue life improvement (e.g., maximizing the amount of the bore of the hole that is cold expanded).
- When analyzing the effect of load on a non-cold expanded hole, you cannot simply superimpose the residual stresses from cold expansion to calculate a new loaded stress state for a cold expanded hole. For the most accurate results, a model should be constructed that includes the residual stresses from the cold expansion process and the actual applied load.

Aircraft designers have taken the results from FTI's FEA and have used the data in their own designs to create structures that are lighter and stronger.

FTI analysis allows aerospace engineers the ability to sharpen their pencils and design or rework their aircraft with a greater understanding and confidence in cold expansion and how its residual stresses can benefit the fatigue life and durability of the aircraft.

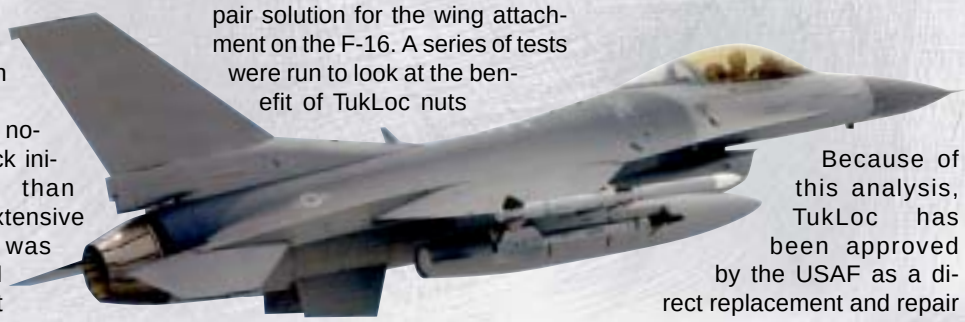
FTI Engineering Analysts Work with Customers to Keep Aircraft in the Air

At FTI, our team of engineers, lab technicians, and Finite Element Analysis (FEA) analysts develop close relations with our customers to help solve complex issues together as a team.

Case in point, a helicopter manufacturer testing an FTI ForceMate® bushing in a lug noticed fatigue crack initiation earlier than predicted. An extensive FEA of the lug was conducted by FTI and revealed that there was an adverse interaction between the residual stresses induced by the ForceMate bushing and the applied surface shot-peening adjacent to the hole.

Through FEA, we were able to change some of the detailed features around the hole to prevent the surface stress interaction. The manufacturer incorporated these changes and confirmed through testing a significant life increase. These changes saved considerable costs in redesign and repair of the lugs and extended the service and inspection life of the reworked part.

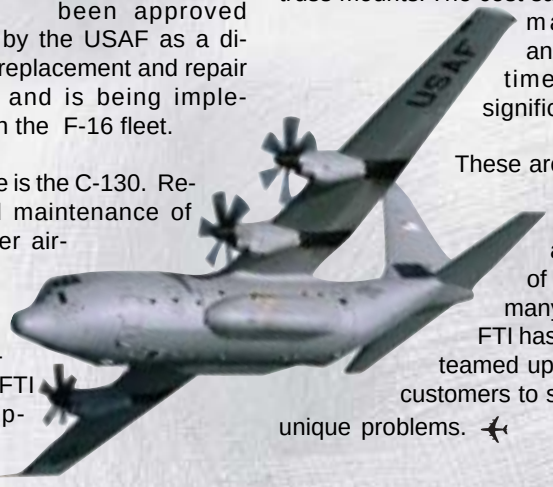
In another example, the USAF was looking at FTI's TukLoc™ Blind Fastening System as a repair solution for the wing attachment on the F-16. A series of tests were run to look at the benefit of TukLoc nuts over the standard NAS 1734 blind nut. The tests showed that TukLoc had a significant life improvement over the other nuts and also performed as good or better than some interference-fit bolts in a bolted joint.



FTI then preformed a 3-D FEA of three types of fastening systems to determine the reason for the test results. The FEA showed that the combination of the residual compressive stress and the interference fit of TukLoc resulted in a significantly less damaging stress state than the NAS 1734 at the edge of the hole. This combination resulted in the improvement over other interference-fit bolts.

Because of this analysis, TukLoc has been approved by the USAF as a direct replacement and repair solution and is being implemented on the F-16 fleet.

Then there is the C-130. Repairs and maintenance of these older airplanes is quite extensive and expensive. FTI was approached to help solve a problem on a particular part located on the wing structure that was extremely expensive to replace.



FTI's analysts worked with the maintenance designers to develop a solution using ForceMate bushings, which resulted in a repaired part that performed as well as a new part.

The analysis satisfied the Air Force and the repair was placed into service. The repair solution resulted in a simpler repair that avoided having to replace engine truss mounts. The cost savings in material and downtime were significant.

These are just three examples of the many ways FTI has teamed up with customers to solve unique problems.

FTI Recognized for International Leadership

FTI was awarded the 2004 **Globe Award** by the Washington Trade Center, rewarding FTI's contribution to our community's international status through trade participation. Nominations were judged based on the following five criteria:

- Expanding the community's trade capacity through jobs or revenue
- Building the community's international status
- Participating in trade and culture exchange
- Heightening community awareness of the importance of international trade
- Being a publicly recognized role model

By expanding into international markets, we have diversified our market to ensure continuous employment – even in down times, such as following September 11, 2001. We have created jobs for 150 FTI families, and another 150+ in our local and international suppliers.

In the past 6 years, FTI total employment has increased by over 70% (from 87 to 151). We regularly use local suppliers for a variety of subcontracts and processes. We have established connections with the local community and trade colleges for specialized machinist training, and ESL training for immigrants. We have also worked with the local high schools and colleges to provide internships for entry-level employees in several FTI departments.

Burke Gibson, FTI CEO and Bruce Gibson, FTI President accepted the award at a presentation on February 2, 2005, in Tacoma WA.

Pushing the Cold Expansion Envelope

FTI is dedicated to furthering the scope and applicability of cold expansion technology which has been around for over 35 years. The technology is well proven and has the ability to solve manufacturing, weight and structural problems on today's high-tech aircraft. FTI is at the forefront of this technology and continues to research and study the effects of residual compressive stress on flying structures.

FTI cold expansion products are simple to install, but the resulting benefits are much more complicated to analyze. There are a large number of variables to consider, including:

- Geometry of the part
- Material properties
- Expansion level

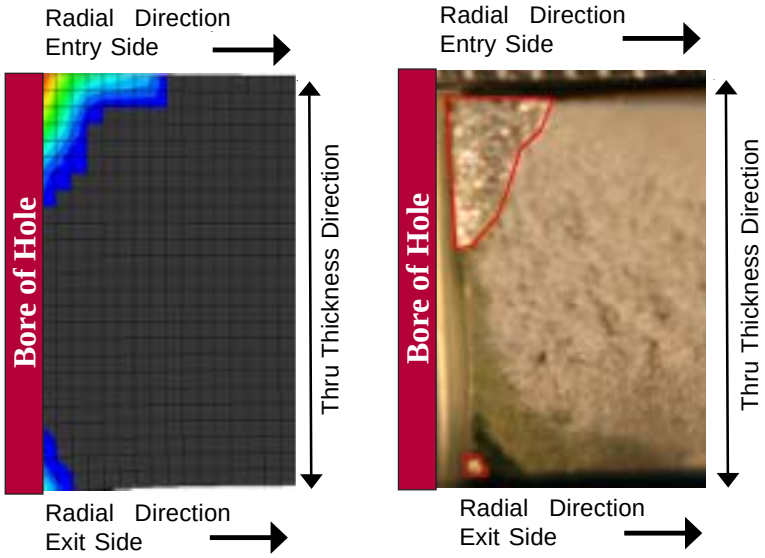
These variables combine in ways that affect the residual stress state, retention of the product, final geometry of the part and response to applied loads. The challenges are becoming increasingly complicated by adding new conditions such as installing products in stack-ups of dissimilar materials or installations in newer high-tech materials such as composites and high-strength aluminum alloys. FEA is an essential tool to quantifying and optimizing the benefits in all cases.

FTI is taking cold expansion research to another level by looking at the prediction of fatigue life and crack growth from cold expanded holes for damage tolerance purposes. The current methods developed outside of FTI to predict the fatigue life and crack growth have not been as accurate as hoped. Our FEA has discovered that in many cases the current analytical techniques for predicting the fatigue crack growth from cold expanded holes are not physically representative of the cracks growing from cold worked holes. In addition, they are very sensitive to error, resulting in the possibility of severely over predicting or under predicting the fatigue life and crack growth rates.

To look at this further and provide a basis for a new method, FTI has embarked on a new research program. After performing and evaluating a series of experiments, we confirmed that there are different amounts of retained expansion through the thickness of a part during cold expansion. This difference in residual stress affects crack initiation and growth.

Our preliminary model has even replicated a similar crack growth pattern that we see with actual cold expanded holes. In the future, FTI hopes to provide a new method for predicting crack growth and fatigue lives of cracks from cold expanded holes and holes with other FTI products installed. This will allow customers to optimize the benefits from these products and to better predict the total life and future inspection cycles (if necessary).

Our research analyst, Dr. Matthew Kokaly, presented a paper on this subject at the 2005 Aging Aircraft Conference in Palm Springs CA. To read the abstract or to download the complete paper, please register on our website at www.fatiguetech.com.



This figure compares the crack front shape predicted from the 3-D FEA model to the unusal P-shape crack front shape from an experiment.

Dr. Matthew Kokaly Heads Up FTI's Analysis Efforts

Dr. Kokaly heads up FTI's analysis area. He has been with FTI for 4 years and his background includes an Undergraduate in Mechanical Engineering from University of Illinois, a Masters and PhD from the University of Washington. His Masters thesis and PhD dissertation focused on the fatigue and fracture of aluminum components and fatigue crack growth in new structural ceramics.

Dr. Kokaly has presented his research for peer review at many aerospace conferences including the ASTM 2004 Symposium on Residual Stress, the USAF Aircraft Structural Integrity Program and the DoD/FAA/NASA Conference on Aging Aircraft.

For More Information:

If you would like more information about the articles in *Focus on FTI*, please visit our web site at:

www.fatiguetech.com

Or contact us at:

Fatigue Technology Inc.
401 Andover Park East
Seattle WA 98188 USA
Tel: 206.246.2010
Fax: 206.244.9886
marketing@fatiguetech.com

2005 Tradeshows and Events

FTI will be exhibiting at the following events. Stop by our display and say hello to our delegates.

April 19 - 21
MRO 2005 Conference
Lake Grapevine TX

May 3 - 5
SAMPE
Long Beach CA

June 1 - 3
AHS
Lake Grapevine TX

June 13 - 19
Paris Air Show
Paris, France

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INSIDE THE APRIL 2005 ISSUE:

FTI®
FATIGUE TECHNOLOGY INC.
P.O. Box 88388
Seattle, Washington USA
98138-2388