Ogden Air Logistics Center

U.S. AIR FORCE

Applications of advanced fracture mechanics utilizing StressCheck and AFGROW

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T-38 Structural Integrity
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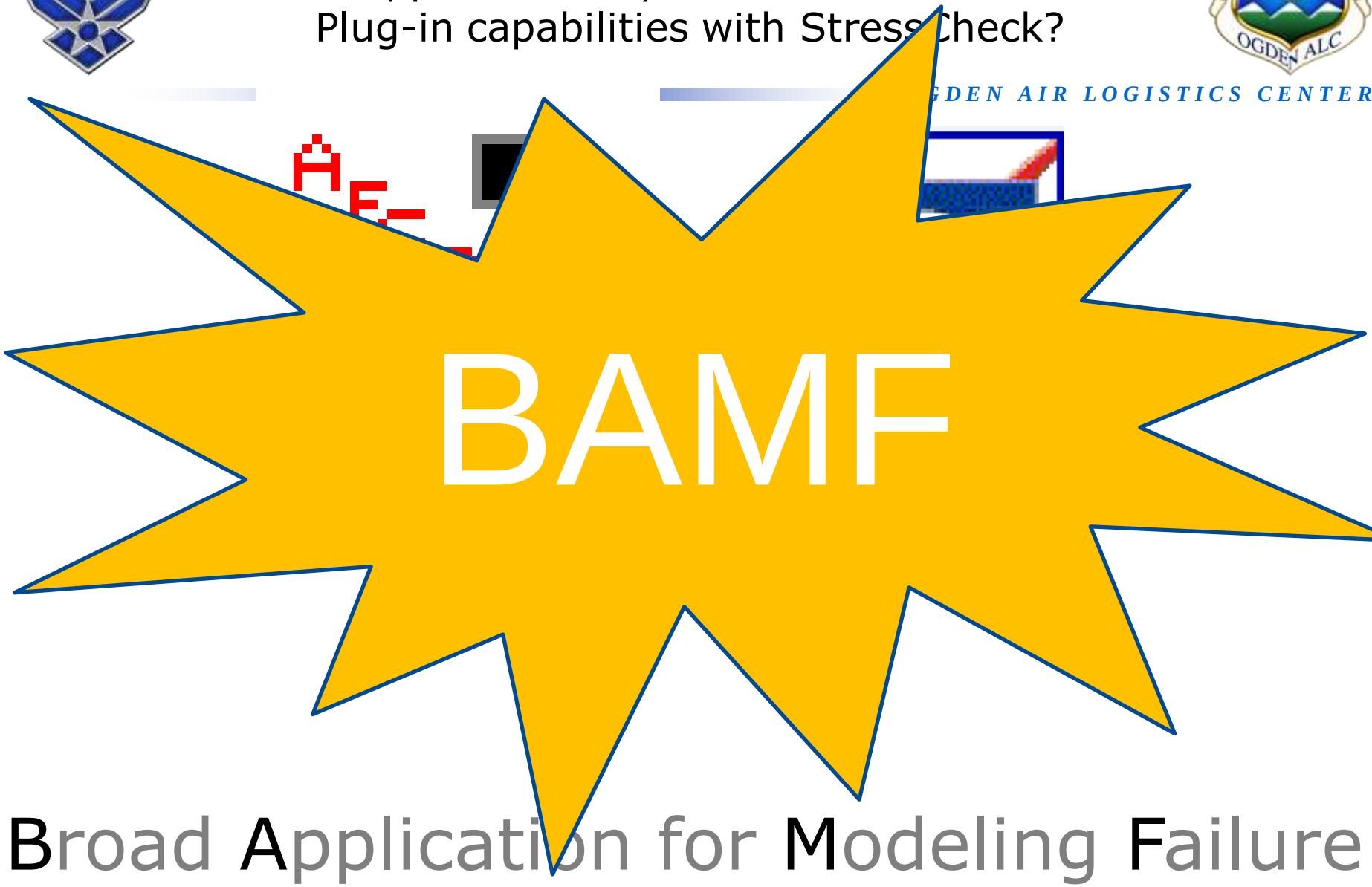
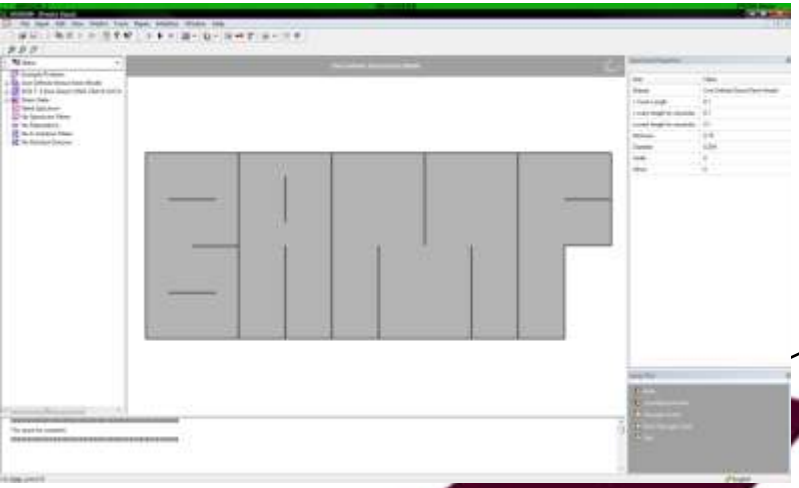
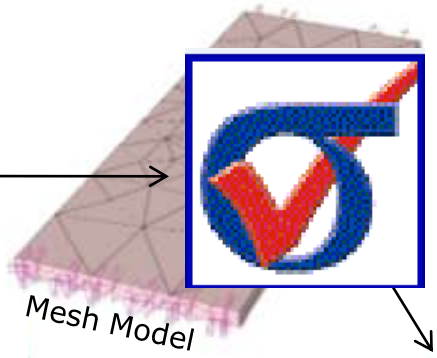
What happens when you intertwine AFGROW 's Plug-in capabilities with Stress Check?



Broad Application for Modeling Failure

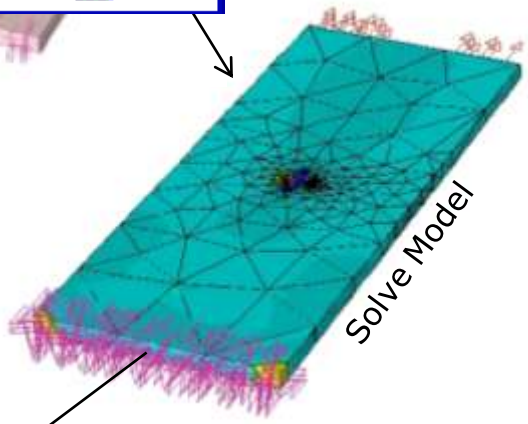
What does BAMF do for you?





Mesh Model

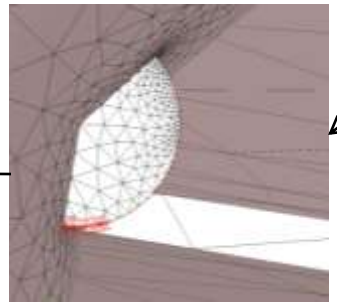
Import Model



Solve Model

$$\alpha = K/\sigma$$

Far field stress
from StressCheck

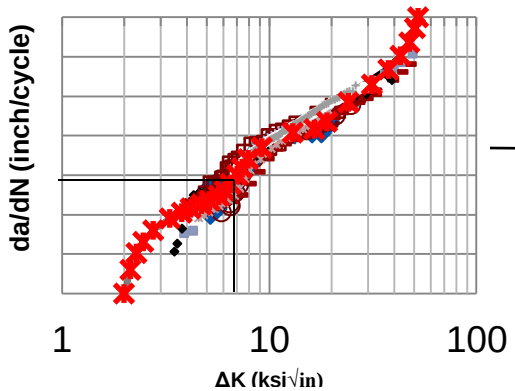


Extract Stress Intensities

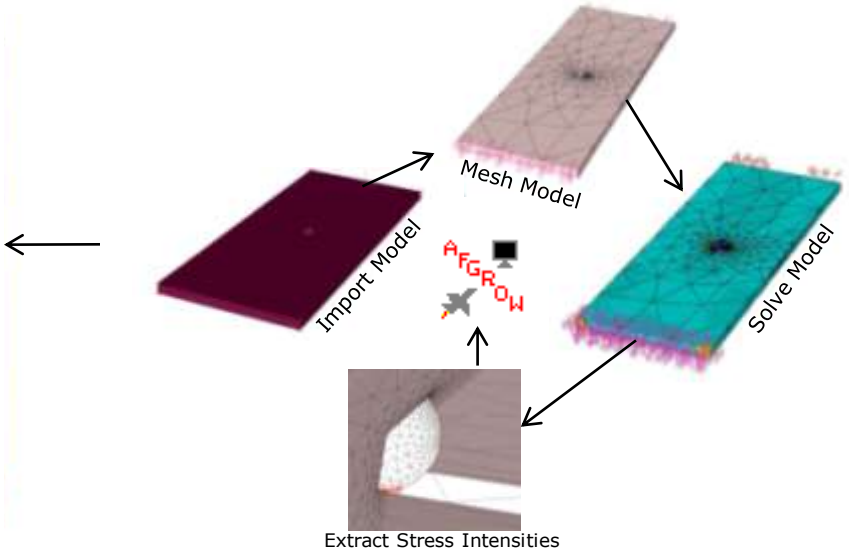
What does BAMF do for you?

$\Delta K = \alpha \Delta \sigma$

Where $\Delta\sigma$ is the AFGROW spectrum stress



New Crack Lengths

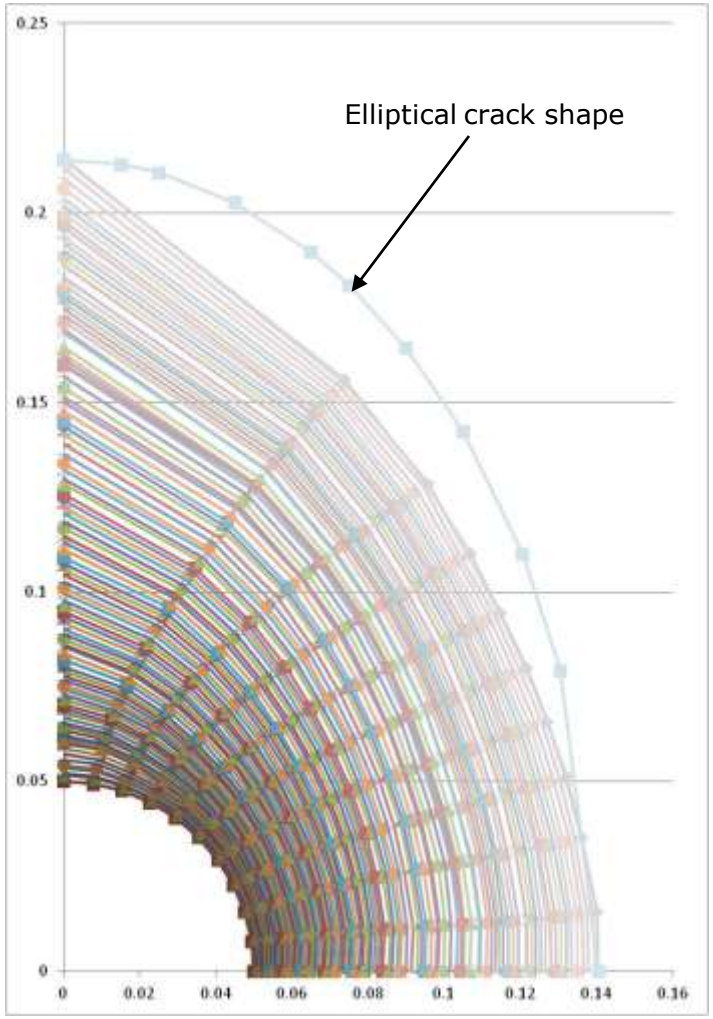


Flavors of BAMF

- **Multi-Elliptical Crack (allows anywhere from 1-10 elliptical cracks in a single body)**

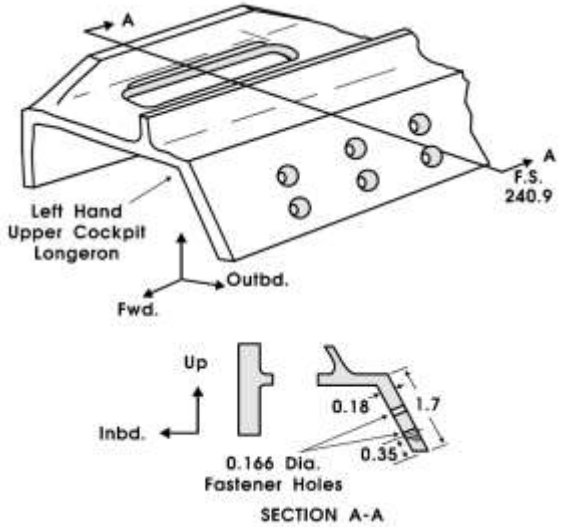
- **Multi-Point Crack Growth (utilizes StressCheck splines to create unique crack fronts)**

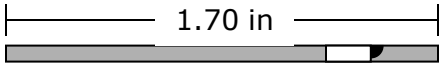
Features of BAMF



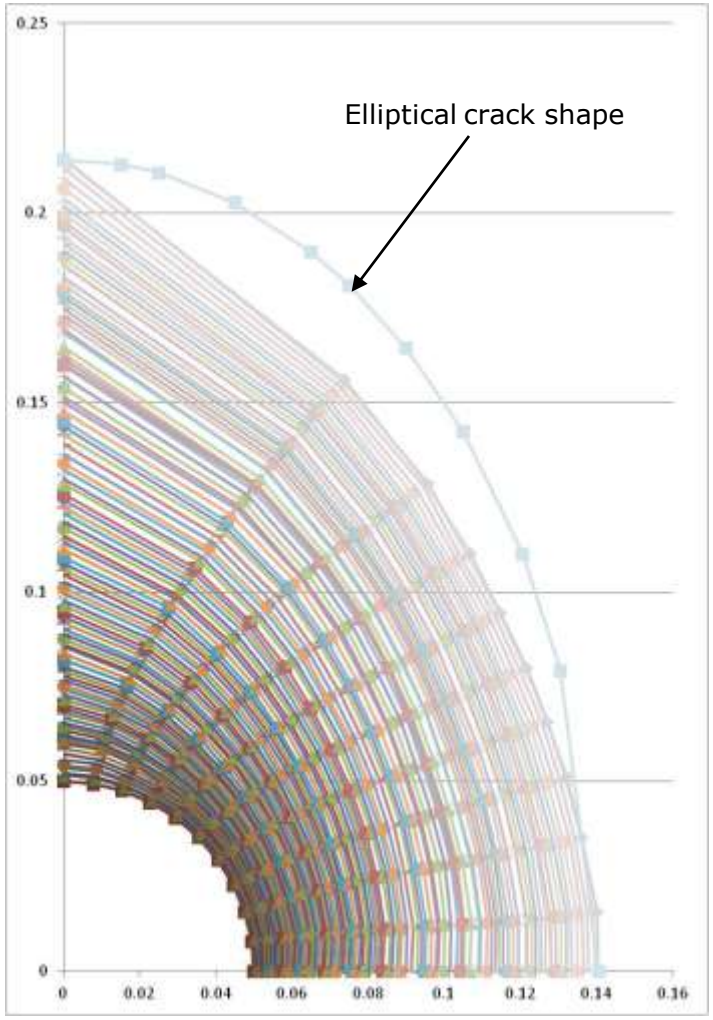
Benefits of BAMF

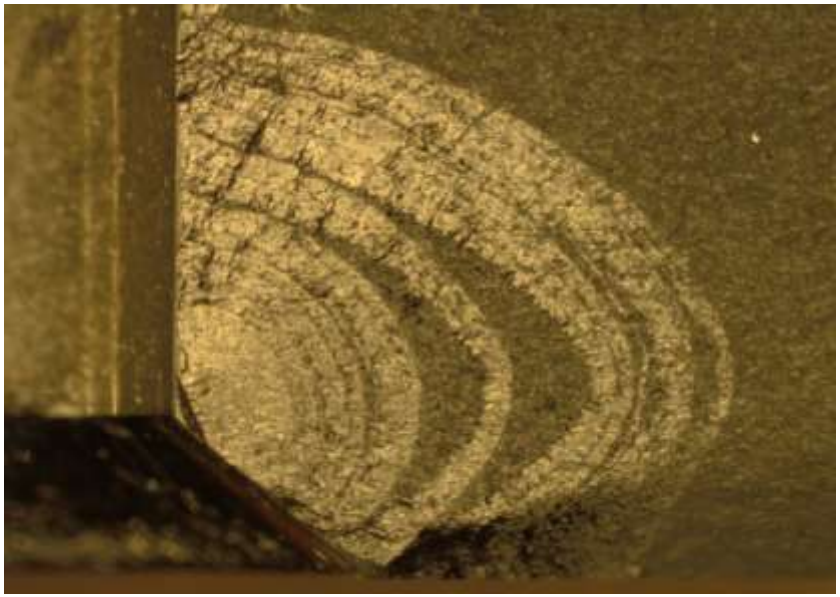
- Removes conservatisms
  - Continuing damage models
  - Multi-site damage
  - Flat plate assumptions
- Reduced engineering judgment
- Reduced engineering time
- Reduced risk





Features of BAMF

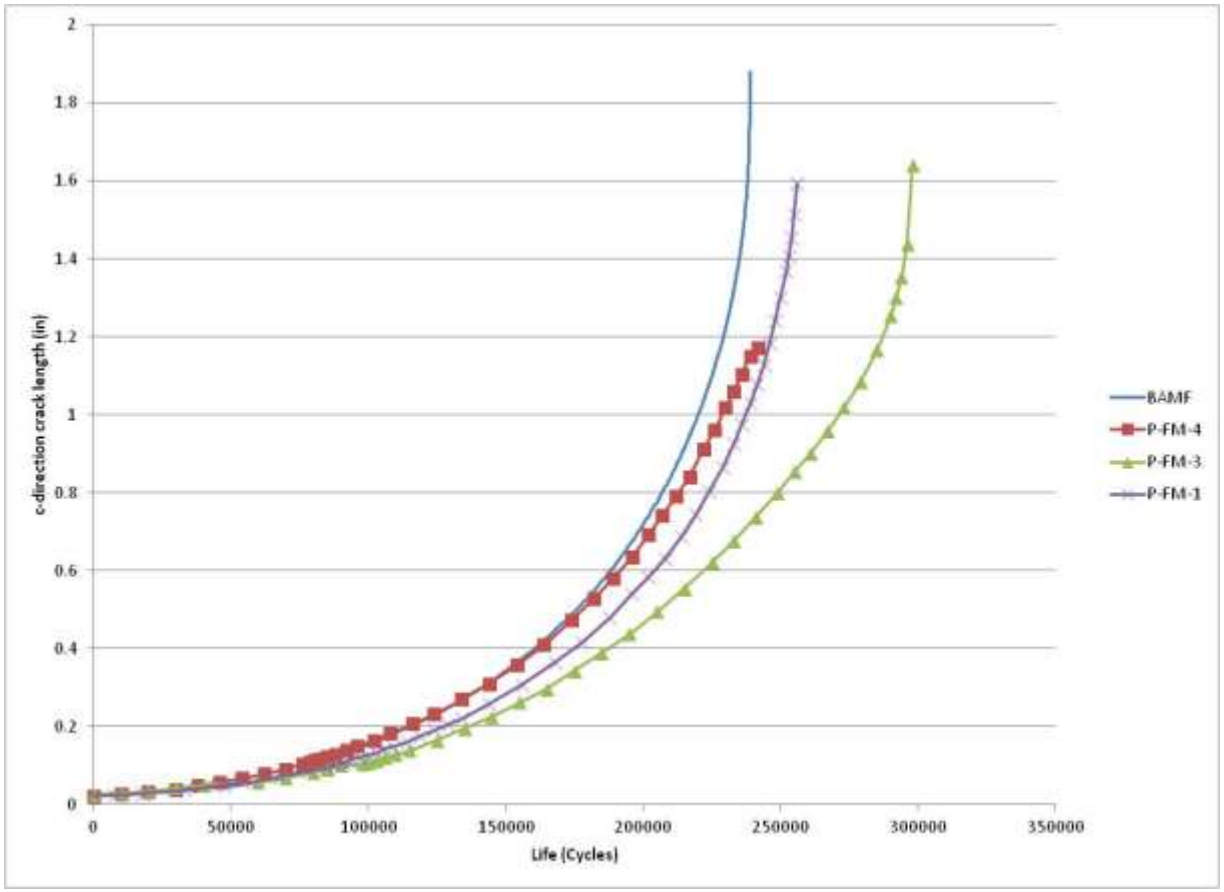


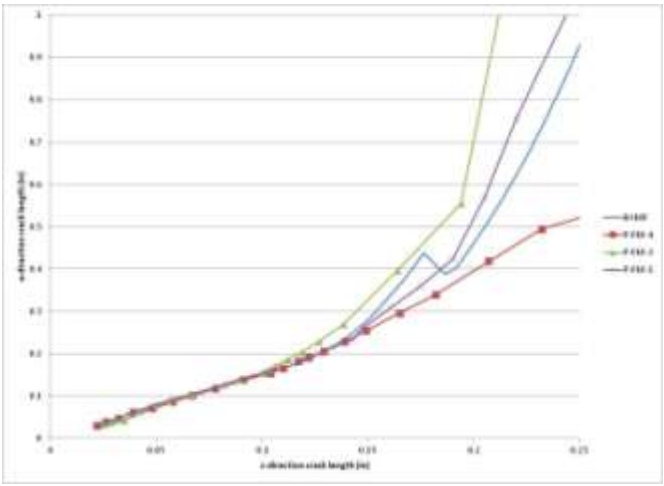


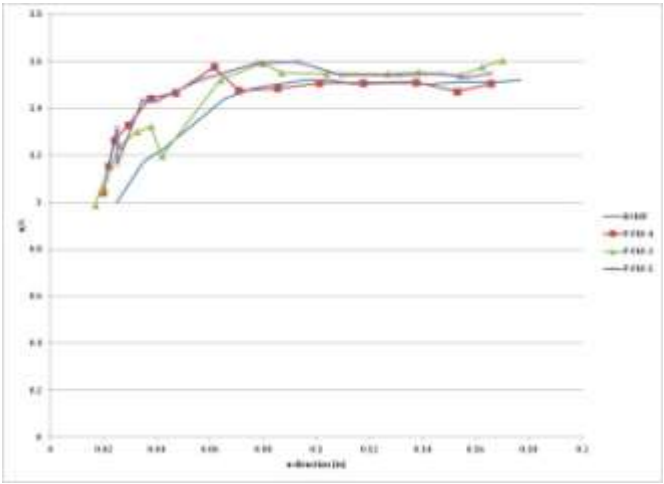
Benefits of Mulit-point BAMF

- Reduction of stress intensities at the bore (compared to elliptical crack assumption)
- More realistic crack shapes (compared to elliptical crack assumption)
- Increased load carrying capability (compared to elliptical crack assumption)
- P-shape and other unique crack shapes

BAMF'n Cracks

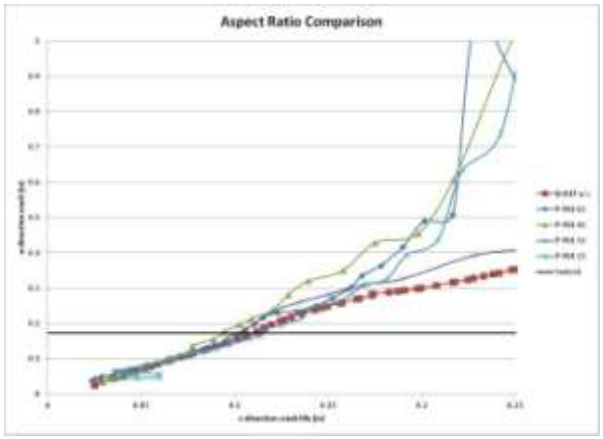


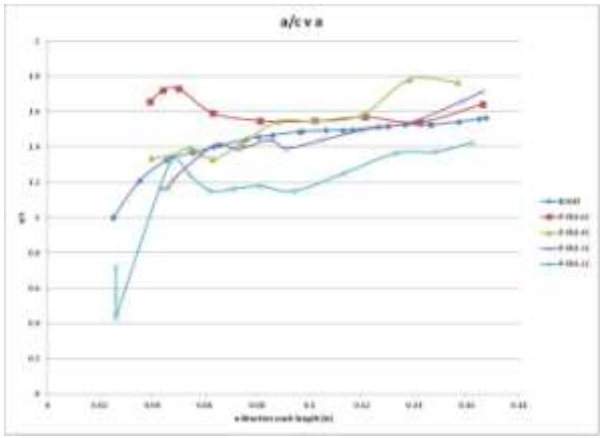


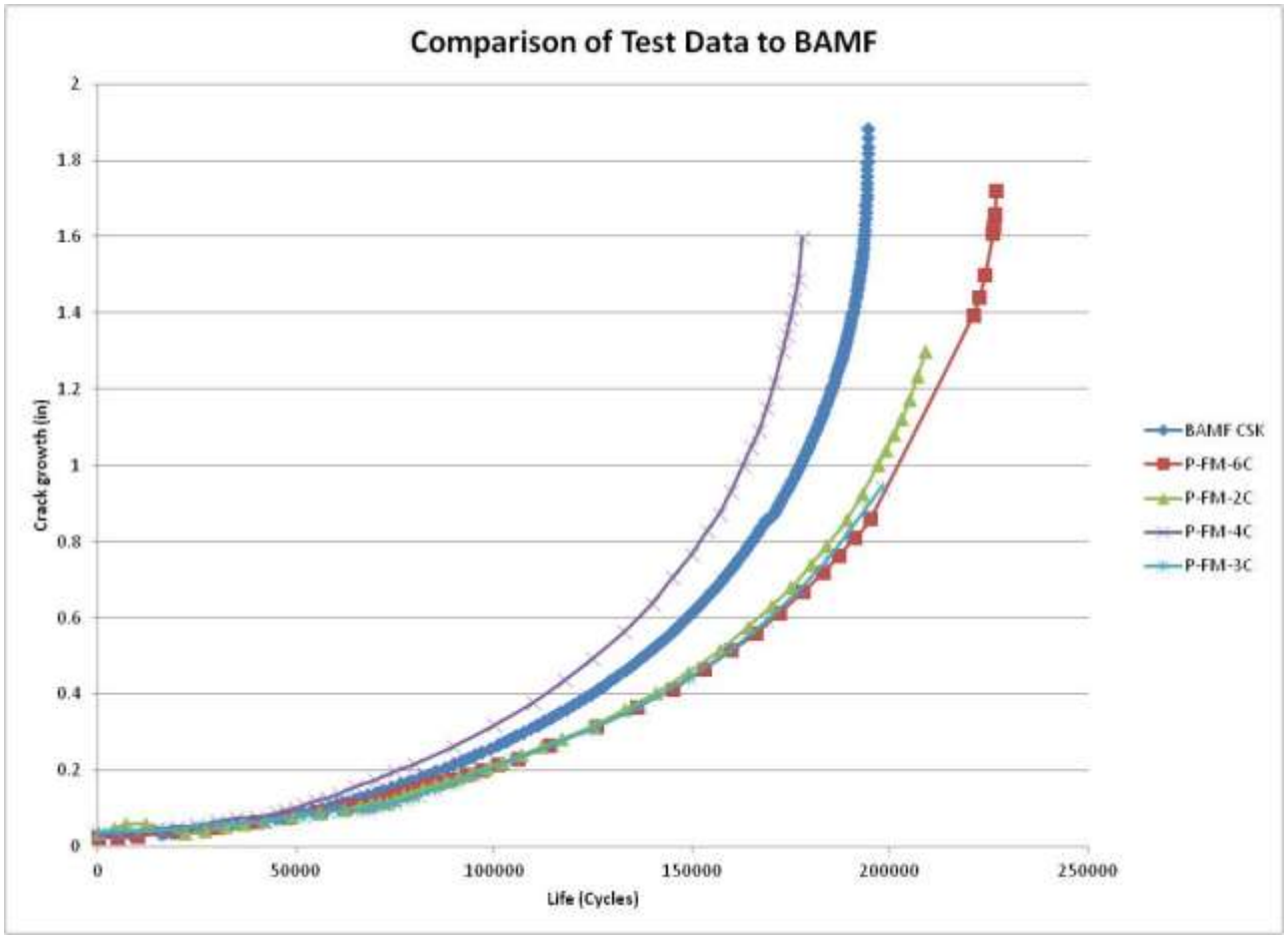


Test data obtained by SwRI: Cronenberger, J. (2011). Mathematical Modeling and Validation of Stress-Intensity Factor Solution for Cracks Emanating from Countersunk Holes, Masters Thesis, University of Texas – San Antonio, San Antonio, TX, USA

BAMF'n Cracks in Countersinks







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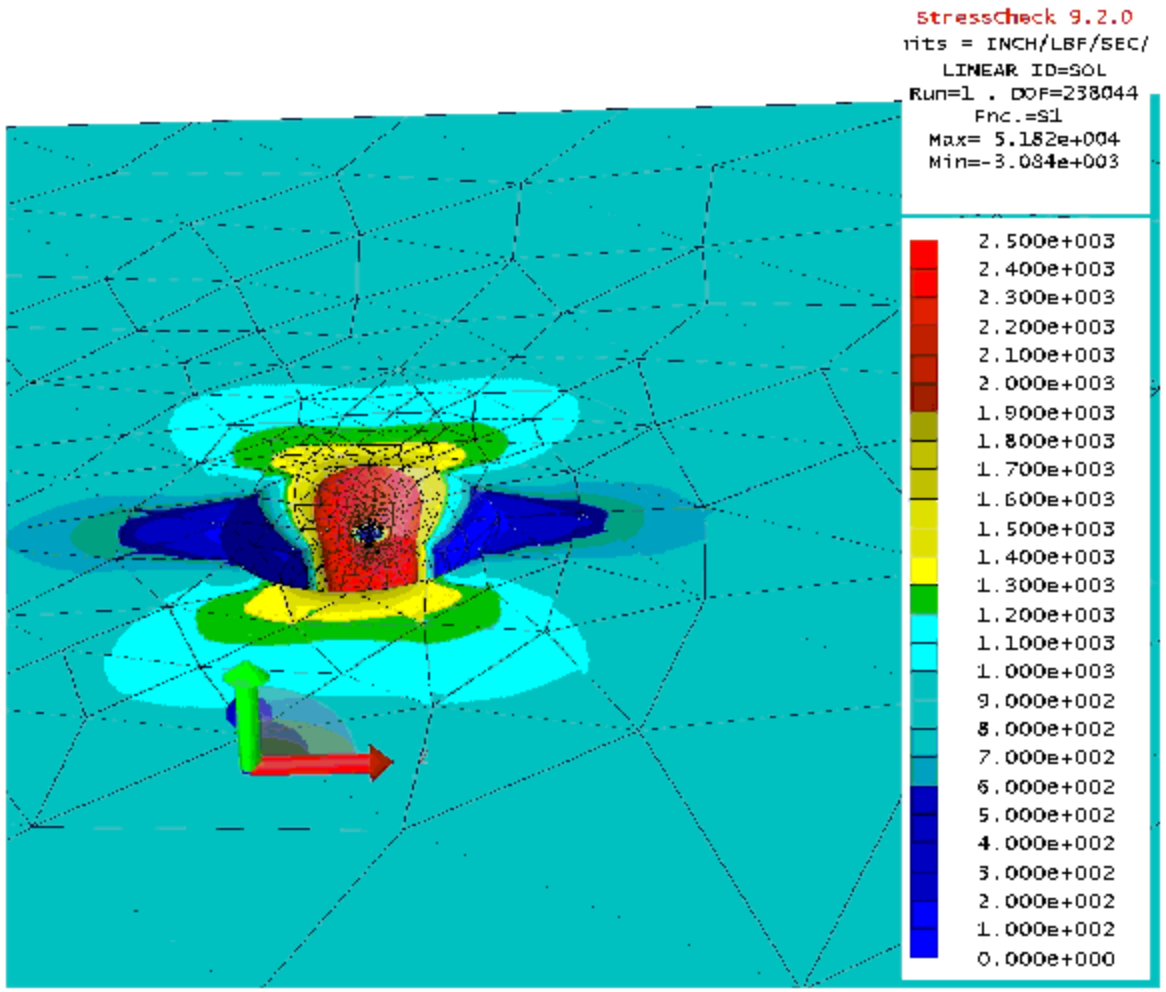
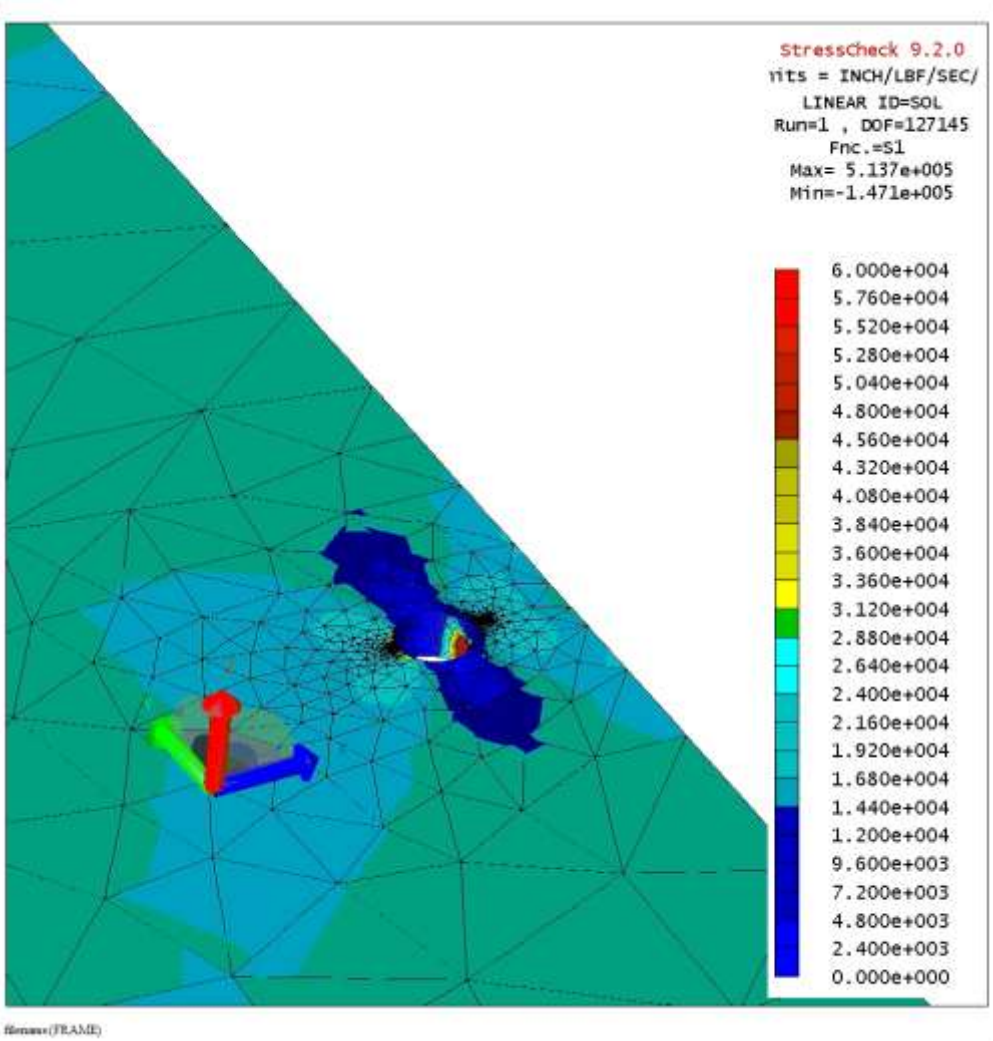
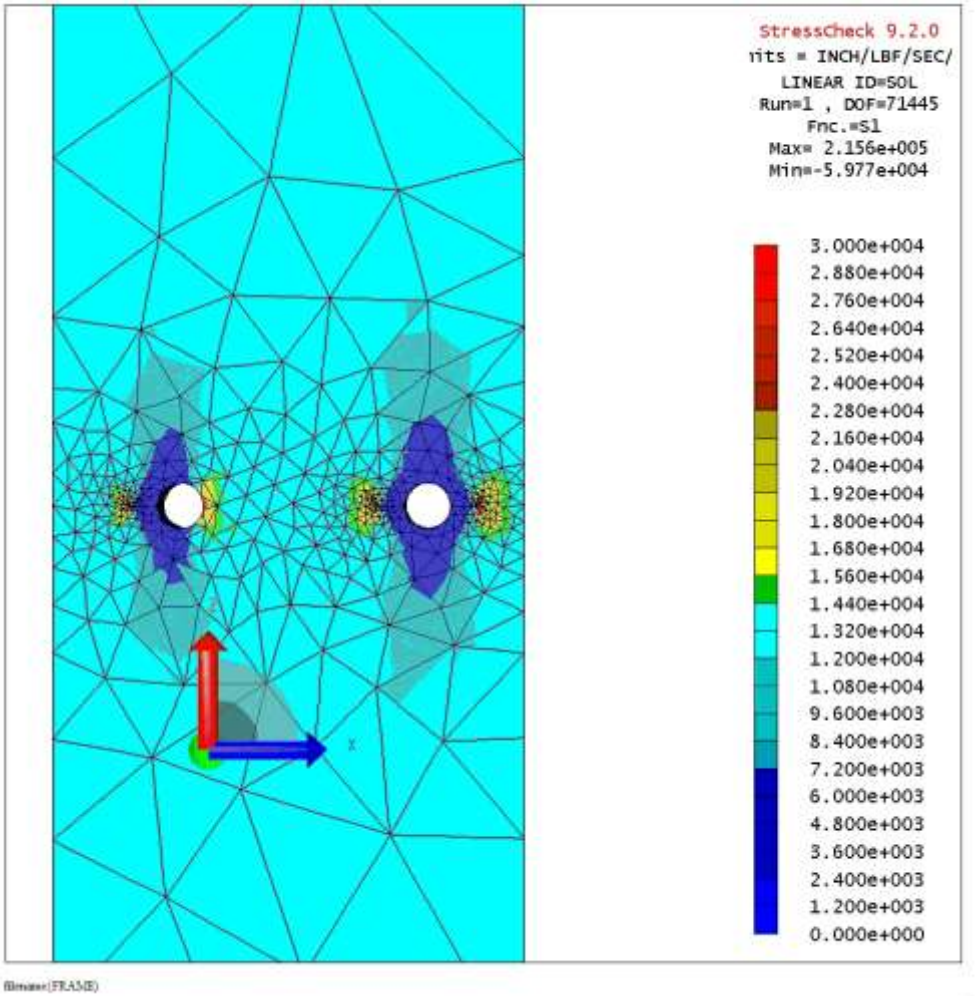
BAMF'n Cracks in Countersinks



BAMF'n 2 Cracks

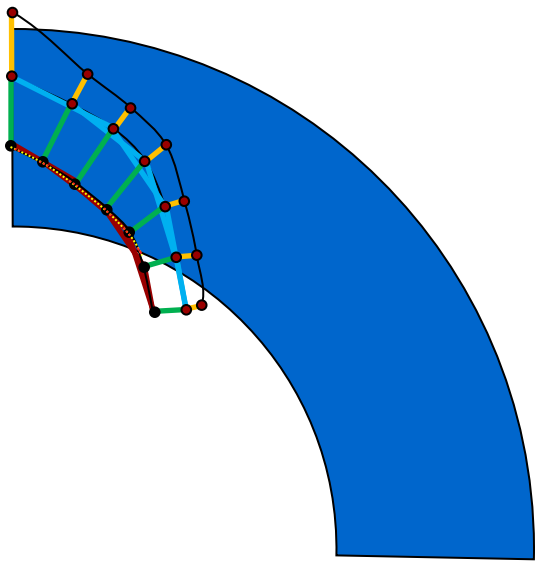


BAMF'n Multi-Crack



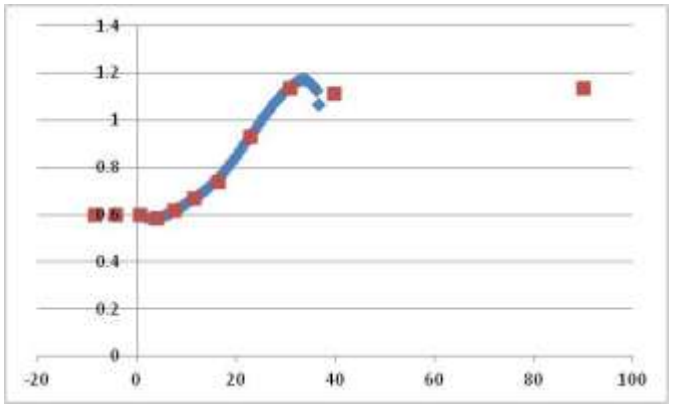
BAMF'n Multi-Point

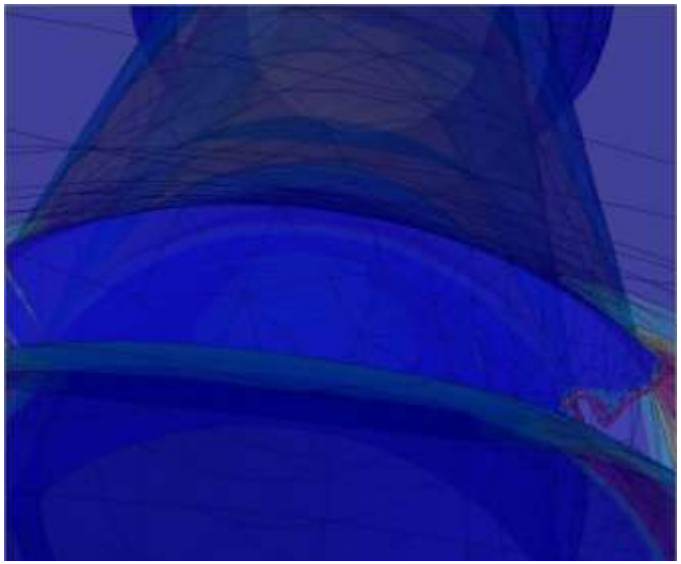
- Points may need to be created that lay outside the body. This will insure that the crack can grow in complex geometries.
- Each stress intensity is calculated from a 3 point average of points on the extracted stress intensity curve.
- The stress intensity at an end point is calculated from 2 points inboard of the extracted stress intensities

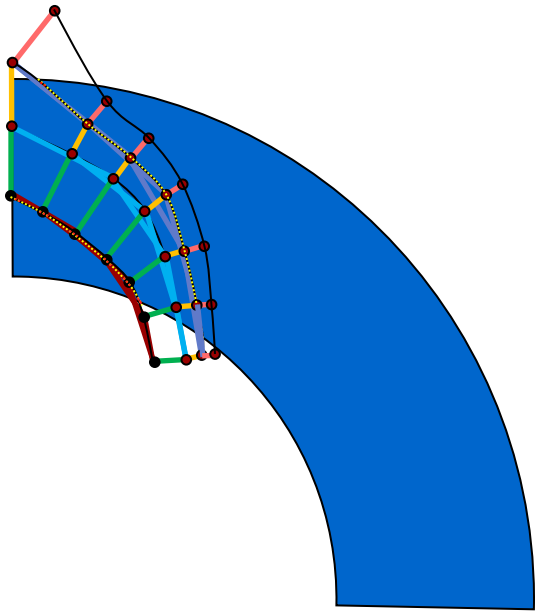


- Initially the 1st point will grow only in the y-direction until that point is no longer on the face of the part
- The cracks will grow a value of da, perpendicular to the line created by its adjacent points.
- If a point is outside the body it will grow based on the stress intensity just beneath its closest surface.

BAMF'n Multi-Point

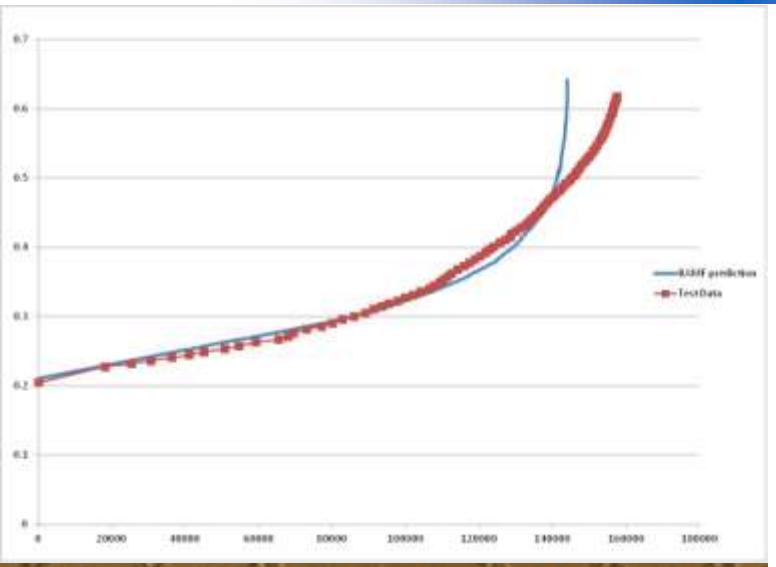


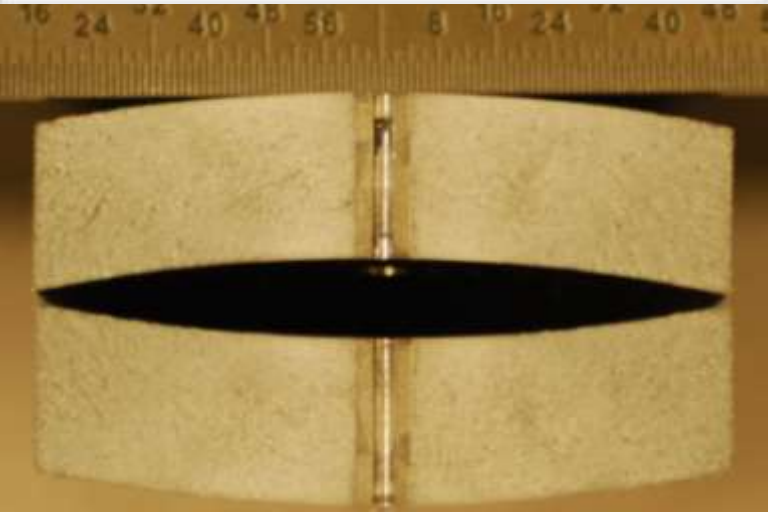


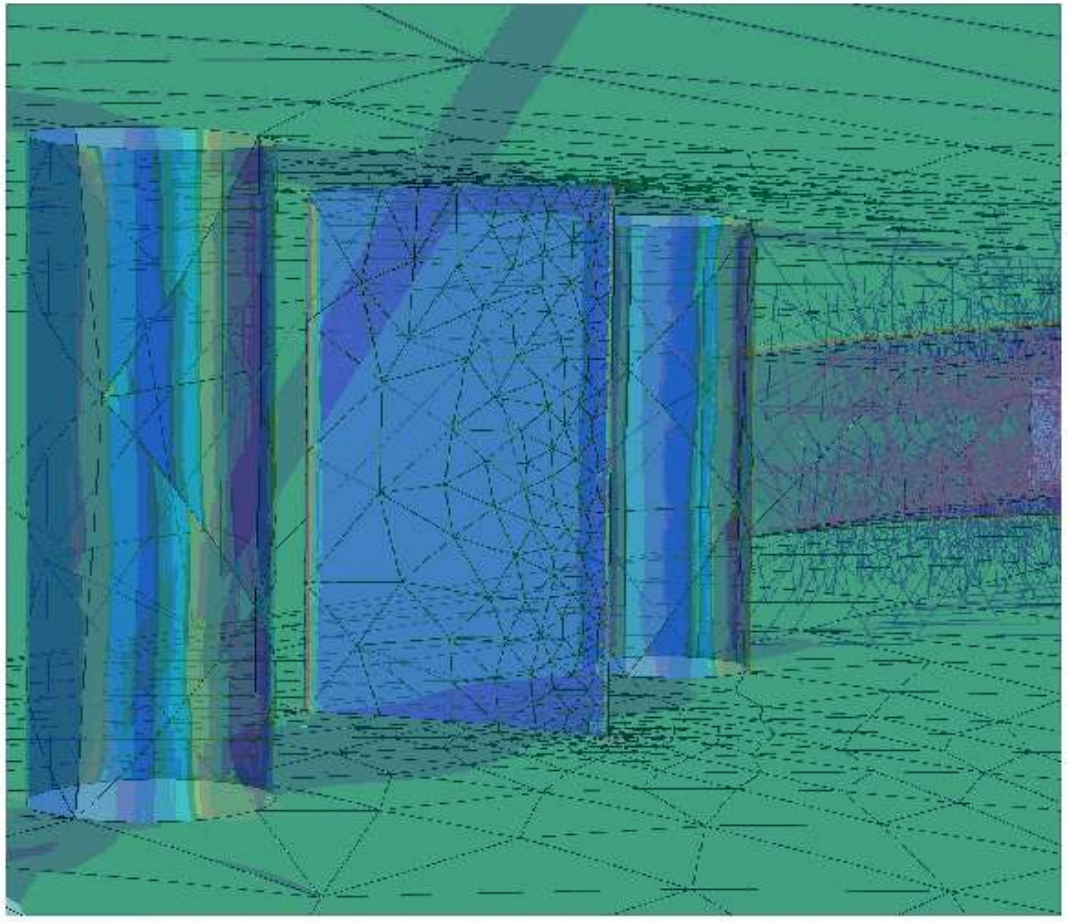


- Once the 1st point leaves the surface it will then grow perpendicular to the line created between itself and its adjacent point.
- Large crack growth increments will harm crack growth shape.
- The larger the crack grows the less accurate its predicted shape becomes.

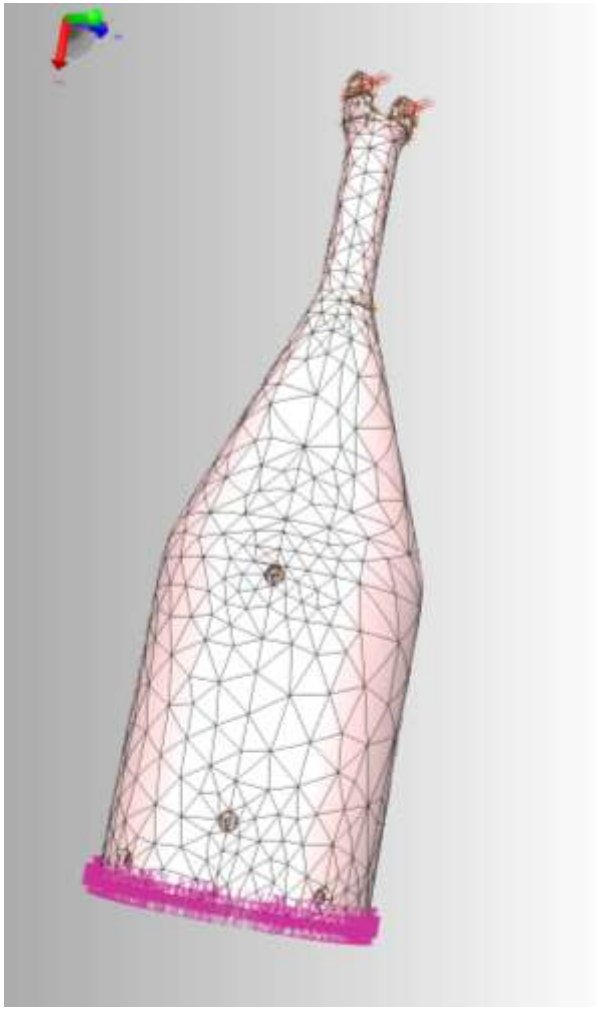
BAMF'n Multi-Point

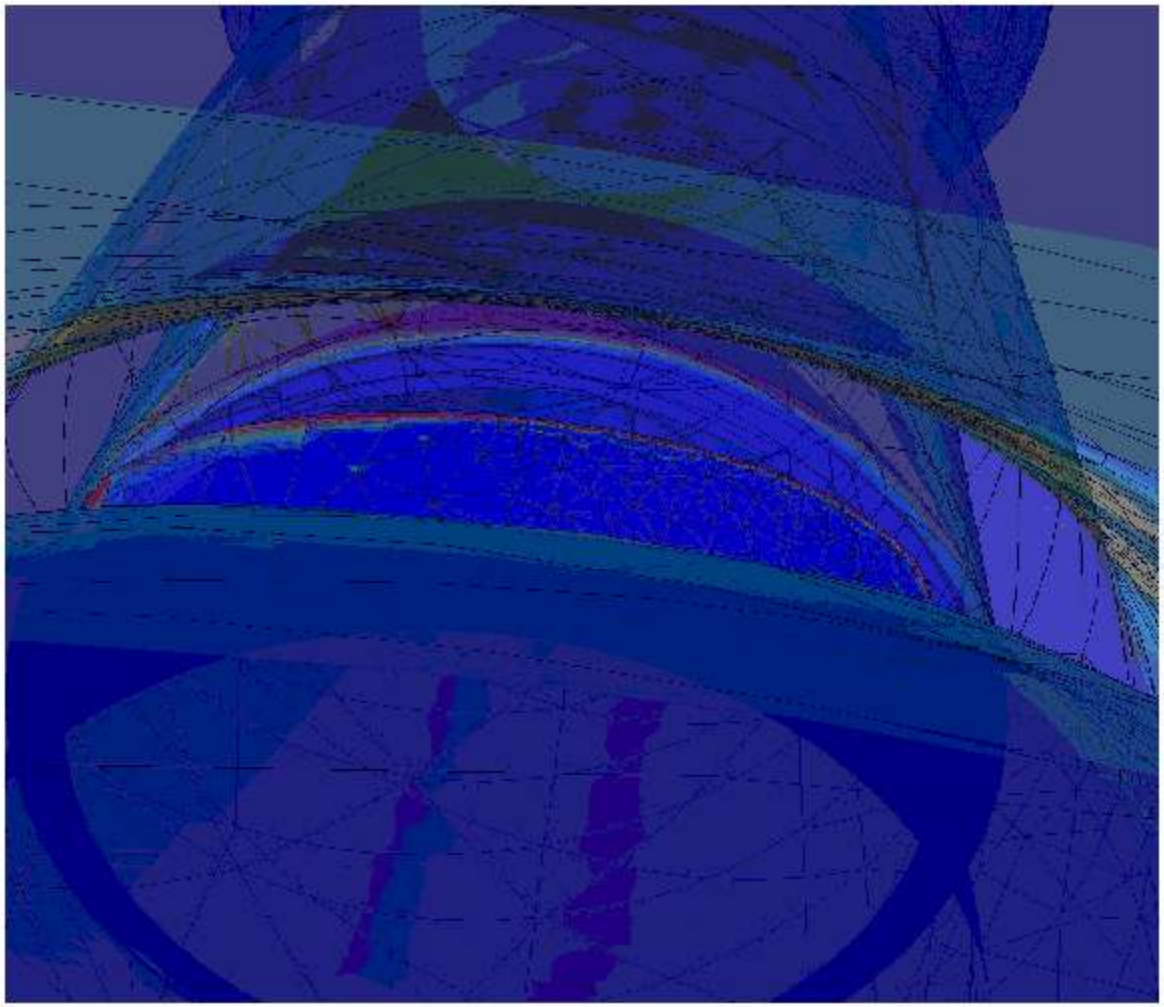






BAMF'n Multi-Point





Discussion of things to be worked on

- **AFGROW ISSUES**
  - **Dealing with small crack lengths <0.05 in**
    - **AFGROW call to "Calculate Beta" subroutine**
  - **Growing Rate of Multiple Points/Multiple Cracks**
- **BAMF ISSUES**
  - **Through thickness failure**
  - **Failure/Fracture criteria (No current failure criteria)**
- **STRESSCHECK ISSUES**
  - **Mesh refinement tools (local curve refinement)**
  - **Multiple points going out of the surface**
  - **Knowing the surface geometry**

Questions/Comments/Concerns