

# Ogden Air Logistics Center



**U.S. AIR FORCE**

## **BAMF with Residual Stresses**

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What happens when you intertwine AFGROW 's  
Plug-in capabilities with Stress Check?



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AFGROW

BAMF

Broad Application for Modeling Failure

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# Discussion of things to be worked on from 2013 AFGROW workshop



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- Integrating with AFOPC 1.18 (32 bit)
  - New capabilities Plug-in
- Integrating with StressFusion (64 bit)
  - Including residual stress box
- Continuing to make improvements to allow for more variability in simulations of crack position
- Continue to compare crack shapes/life to BAMF outputs from D-1 SOLR testing



# Upgrades From Last Year



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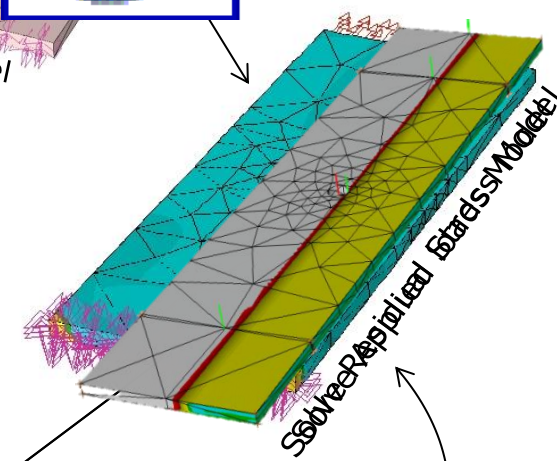
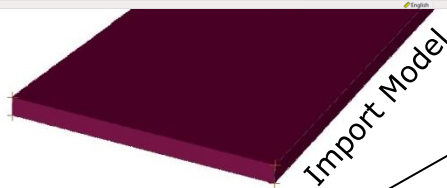
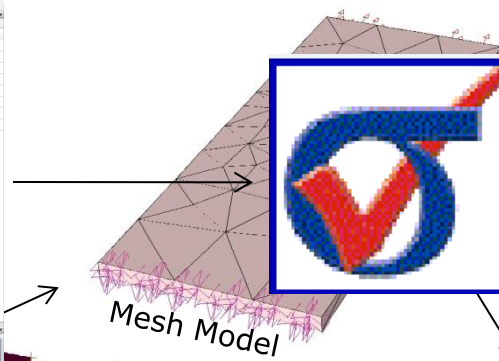
- **Addition of capability to add residual stress fields**
  - **Spectrum/Load Interaction Models**
- **Interpolation Schemes to handle invalid splines**
- **Running beach mark plot to help user determine errors in crack progression**
- **VBA code to build BAMF models for the user from an un-cracked model**
- **Comparisons with test specimens (Carlson)**



# What does BAMF do for you?

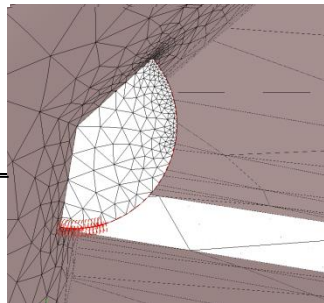


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$$\alpha_{app} = K_{app} / \sigma$$

Far field stress from StressCheck



Extract Stress Intensities  $K_{app}$



# What does BAMF do for you?

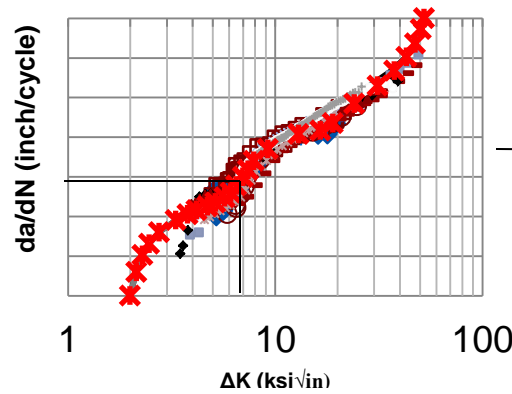


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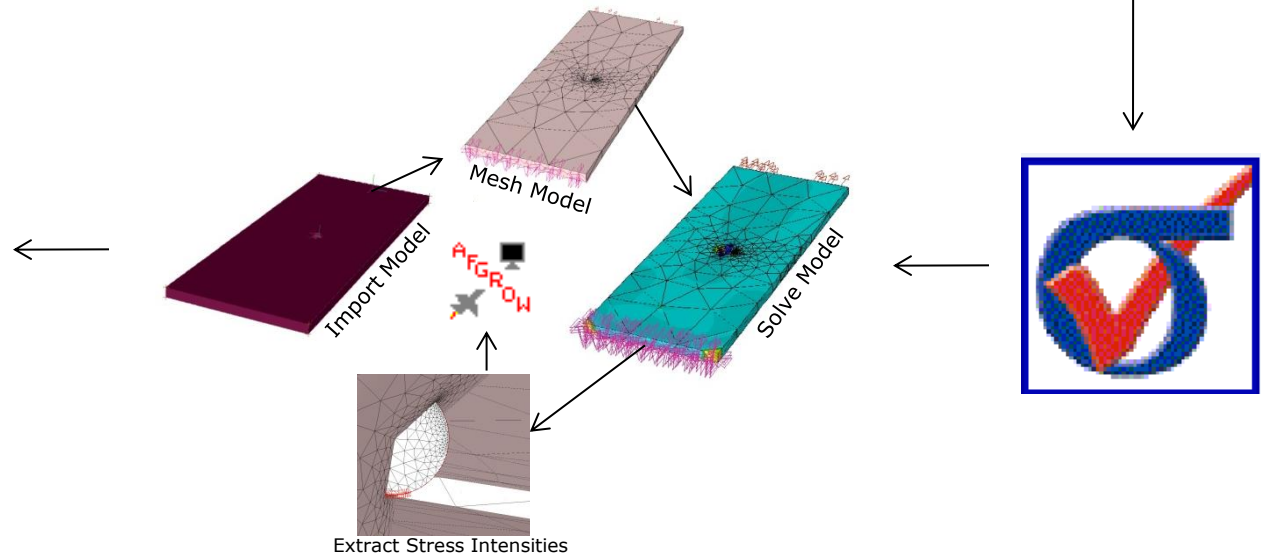
$$\Delta K = \alpha_{app} \Delta \sigma + K_{res}$$

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

$$R = K_{min} / K_{max}$$



→ New Crack Lengths





# Negative R's

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$$K_{\min} = \alpha_{\text{app}} \sigma_{\min} + K_{\text{res}}$$

$\alpha_{\text{app}} \sigma_{\min} < K_{\text{res}}$  R will be less than 0

$$K_{\max} = \alpha_{\text{app}} \sigma_{\max} + K_{\text{res}}$$

$R < R_{l_0}$  then  $\Delta K = K_{\max}$

$$R = K_{\min} / K_{\max}$$

This means for a constant amplitude run for most common cold work holes the lives will be the same for  $R \sim < 0.5$

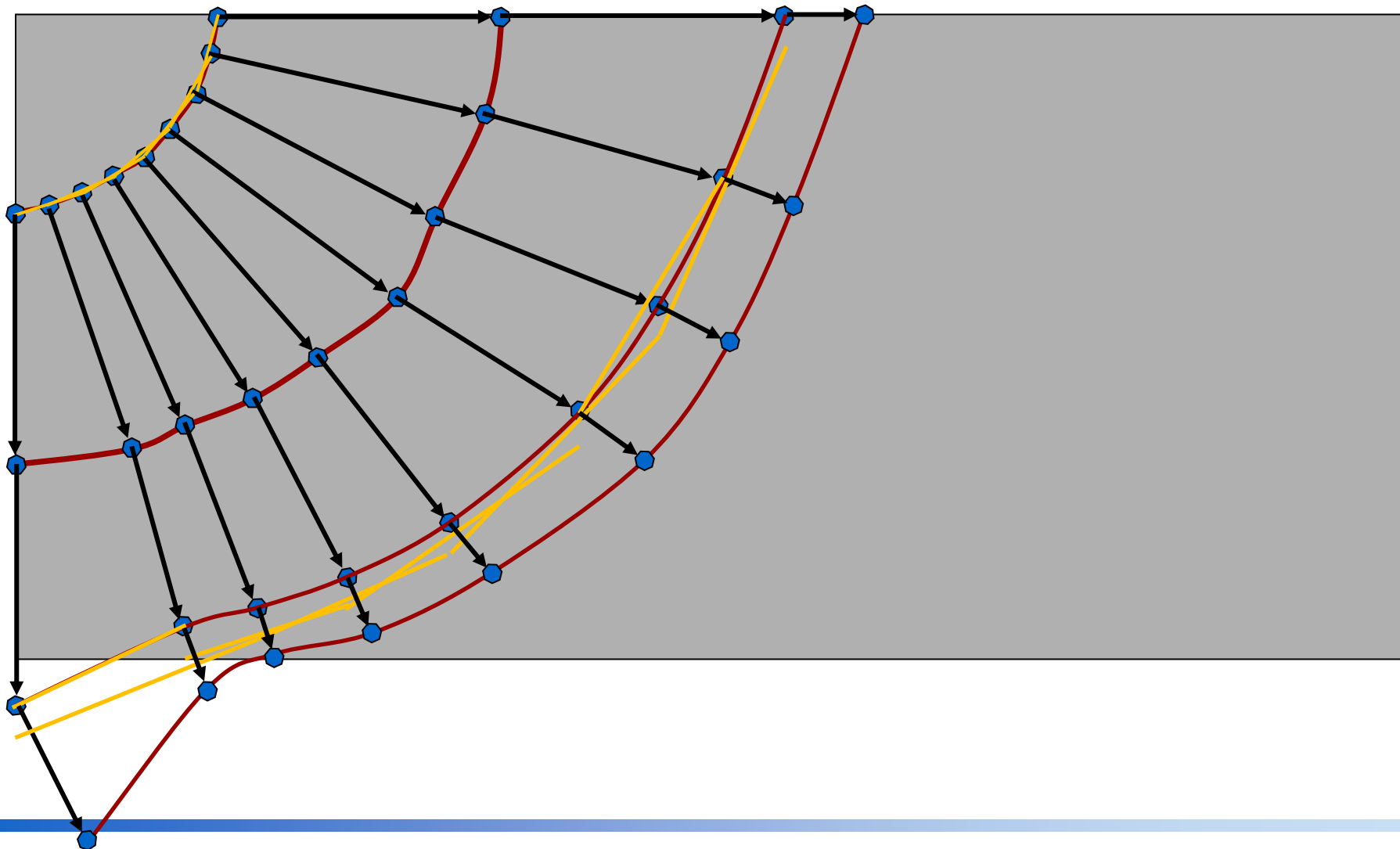
Is this True? Will we see this in Tests? If Mills Didn't talk me out of a PhD we would have known the answer



# Adjusting the code to account for Residual Stresses



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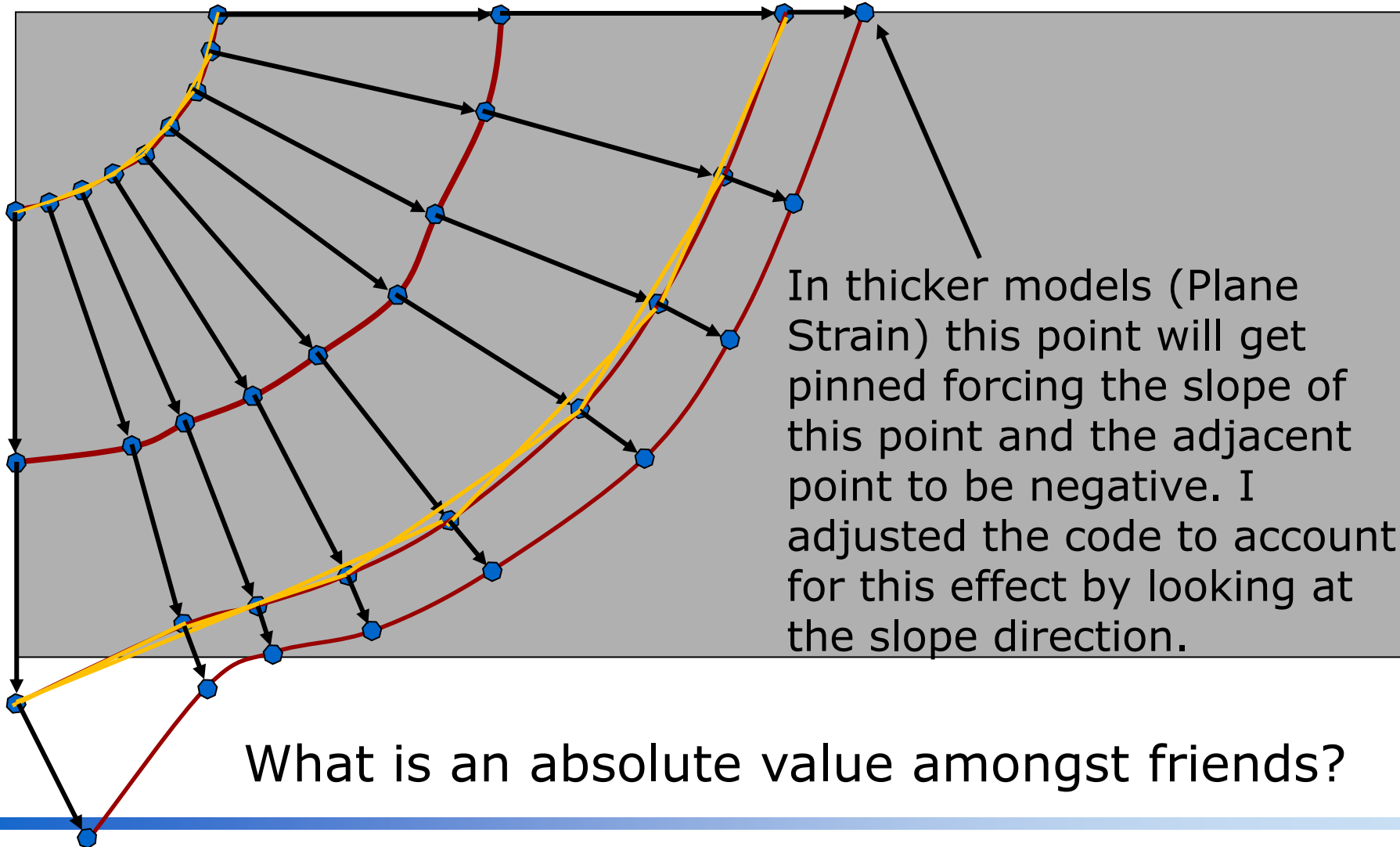




# Adjusting the code to account for Residual Stresses



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In thicker models (Plane Strain) this point will get pinned forcing the slope of this point and the adjacent point to be negative. I adjusted the code to account for this effect by looking at the slope direction.

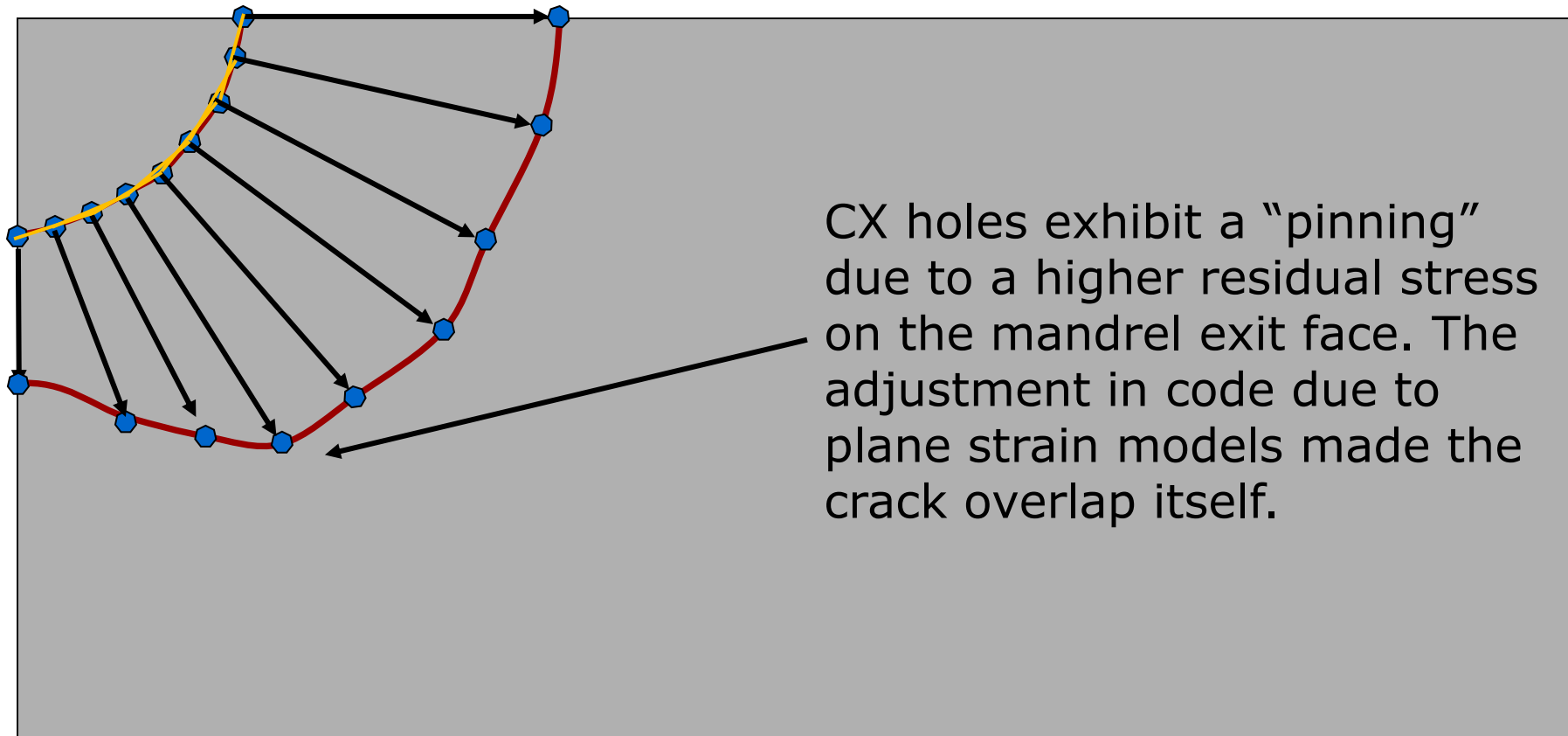
What is an absolute value amongst friends?



# Adjusting the code to account for Residual Stresses



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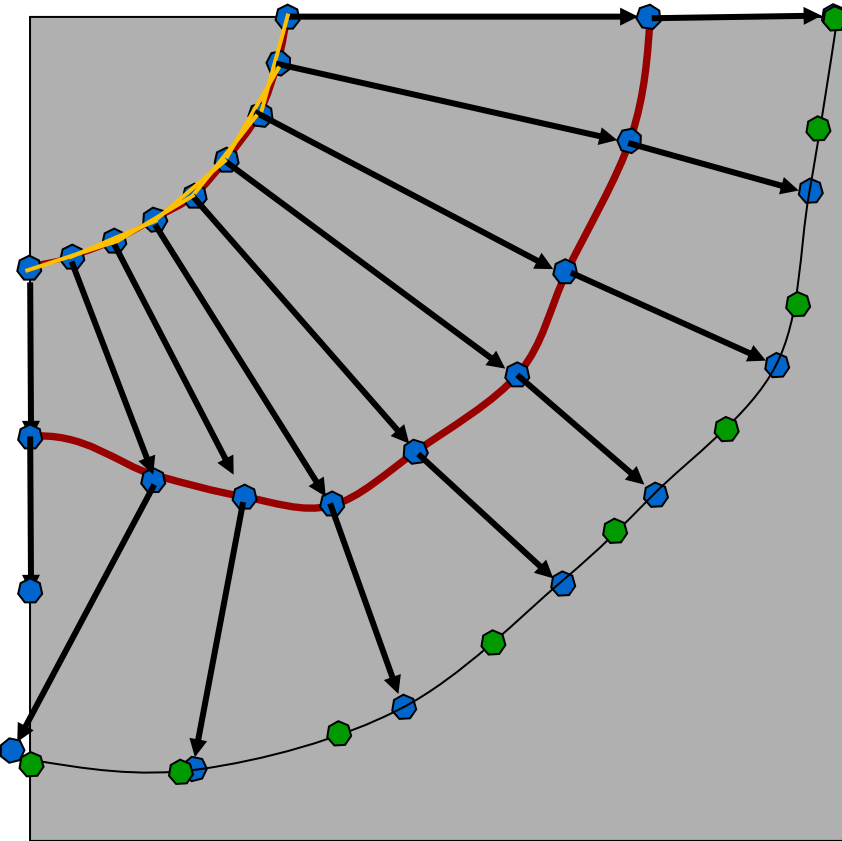
CX holes exhibit a “pinning” due to a higher residual stress on the mandrel exit face. The adjustment in code due to plane strain models made the crack overlap itself.



# Adjusting the code to account for Residual Stresses



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Cubic spline interpolator defined 1000 points on the surface. Those were used to estimate the arc length of the curve and re-space the points equally on the curve.

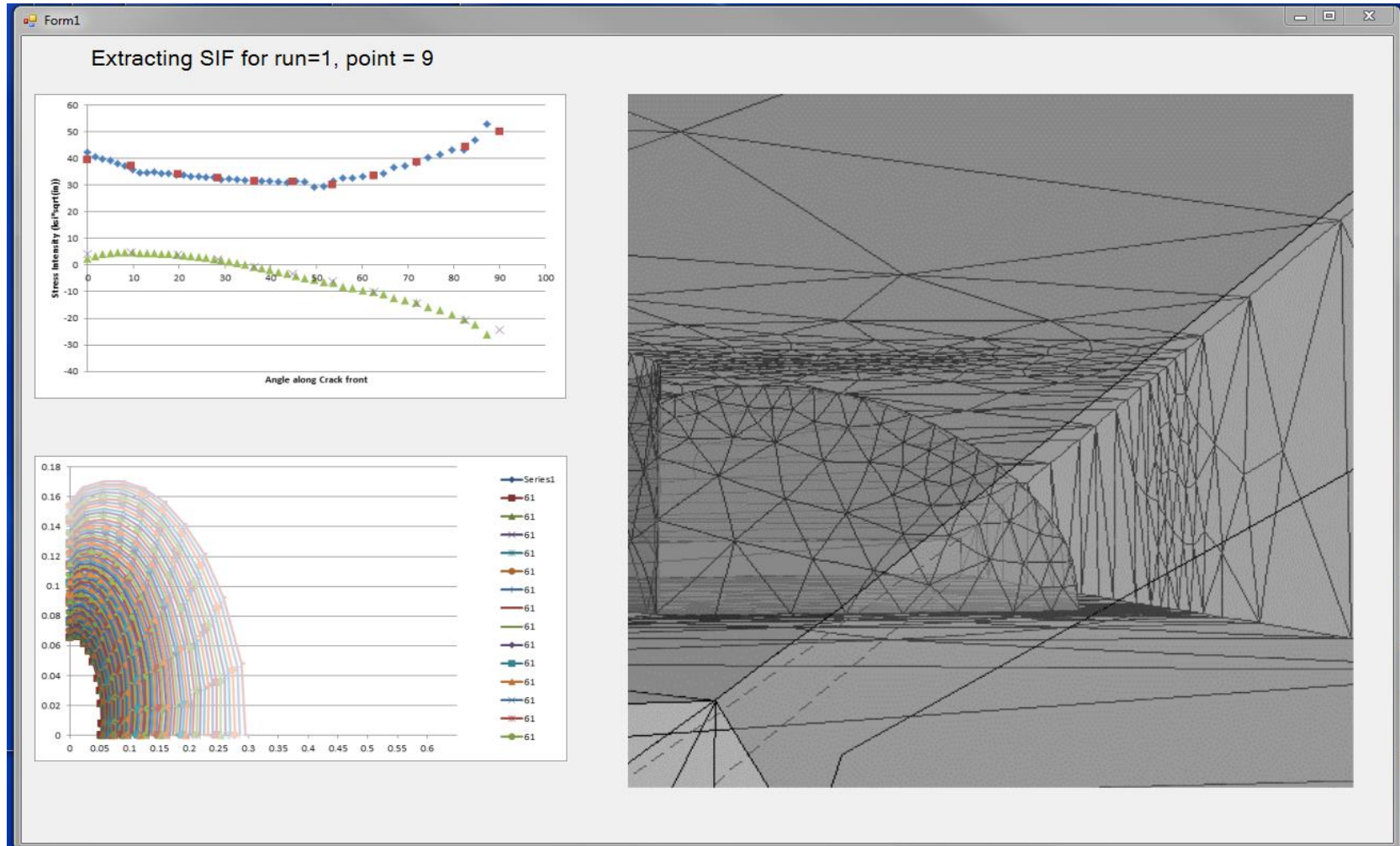
Do not re-space points every iteration only when they go outside the defined surface or after a certain number of iteration. Points tend to congregate in areas of interest.



# Running Beach Mark Plot



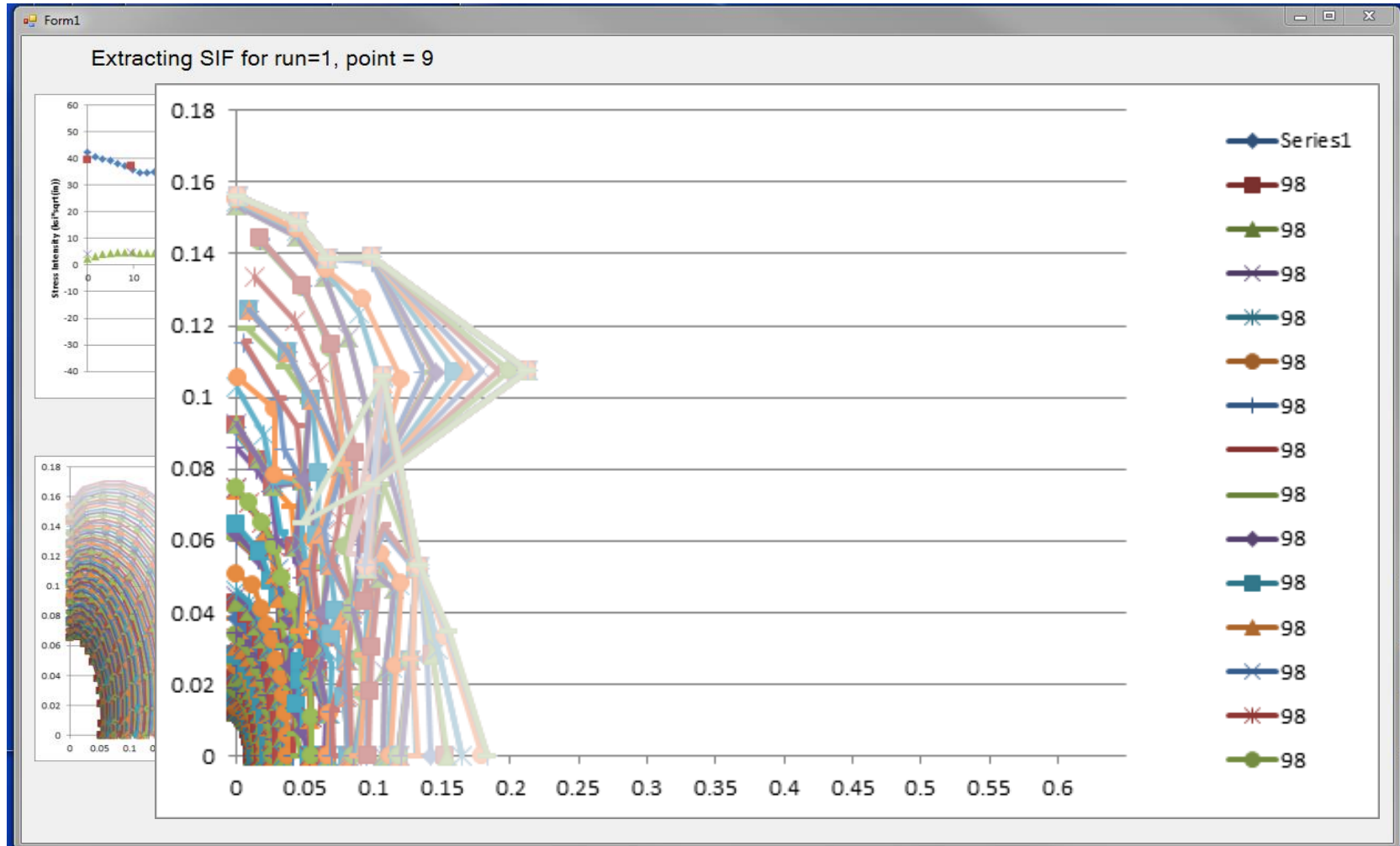
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# Running Beach Mark Plot

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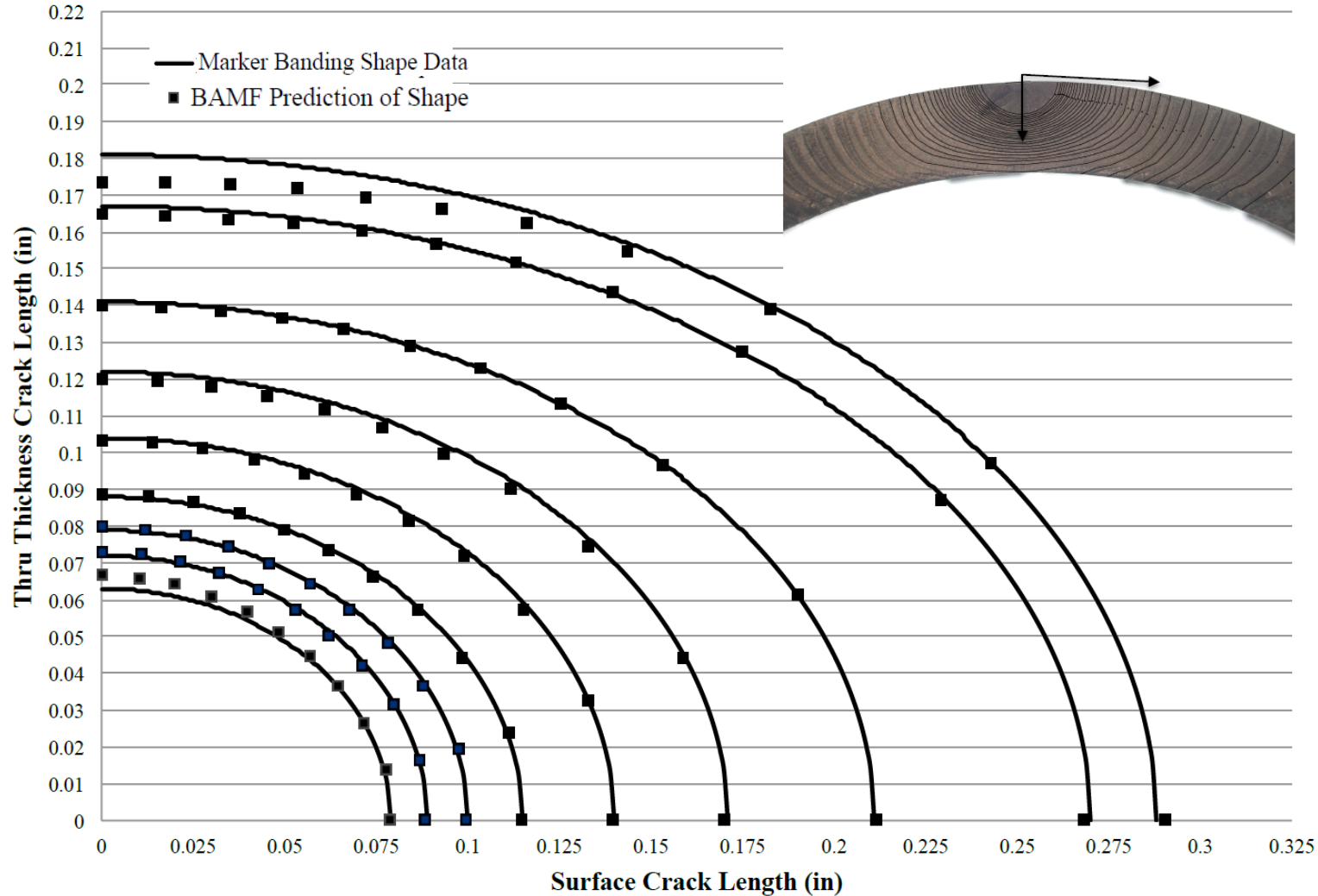
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# Fatigue Crack Growth Test Data of Torque Tube Showing Marker Banding Crack Sizes with BAMF Prediction



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# Automated Model Builder



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- Takes away the guess work of model building
- User supplies an Un-cracked model with Loads and Boundary conditions defined by sets.
- Automates almost the entire process, user needs to provide very little input to make the model BAMFable
- Demo Time!!!