

Interference Fit Fastener Prediction Challenge

APPENDIX A QUESTIONNAIRE

Contact Name: B-2 Spirit

Collaborators:

Name:

Organization:

Name:

Organization:

Please provide information about the analyses completed:

1. Analysis Software (name and version)
 - a. FEA software (if applicable): Nastran 2019.1
 - b. Crack growth software: NASGRO(R) v9.20 alpha

2. FEA Model Setup (if applicable)
 - a. Describe the boundary conditions utilized in the FEMs, to include applied loads and constraints

A quarter symmetry plate model was created of the three conditions. Symmetry boundary constraints were used on the two planes of symmetry. A RBE2 element was used to apply a 8370 lb. load for the max stress case. A 837 lb. load was applied for the 10% load case. For the two interference conditions grounded gap elements were used with a initial gap define to match the interference.

- b. Describe the methods to define and control the crack front shape and control meshing along the crack front

Not applicable.

3. Interference Fit Modeling
 - a. Describe the methods used to characterize and incorporate the effect of the IFF.

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For Condition 2 and 3 grounded gap element were used to apply the initial interference and the model was analyzed for the max and min load case. The resulting stress gradients were then used in Nasgro to account for the IFF.

- b. If the fastener effect was derived from a closed form solution, what were the assumptions of the solution. Is the solution based on empirical data or FEM correlations?

Not Applicable

- c. If the fastener was modeled using FEA, does the model consider non-linear effects? Was multi-body contact used? If contact was used, what friction related assumptions were made?

The model was a simple linear elastic analysis since the interference stresses magnitude were well below the yield stress given for this material. The gap element had a compression stiffness of 30000000000, tension stiffness of 0, and friction coefficient of 0.61.

4. Stress Intensity Calculations

- a. Describe the methods used to extract and calculate the stress intensities for applied remote loads

The stress gradients were normalized and input to Nasgro solution CC08. Nasgro Crack case CC08 is a weight function solution for the corner crack at an off-center hole in a finite width plate with a general nonlinear stress distribution.

- b. Describe the methods used to incorporate the stress intensities into the crack growth code (superposition, etc.)

CC08 has the capability to use two stress gradients t_1 and t_2 . The capabilities of t_1/t_2 stress gradients is provided for a user to specify two sets of stress gradients in crack growth analysis, one for the time instant t_1 of cyclic loading and the other for the time instant t_2 . The stress intensity factors at t_1 and t_2 are

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calculated by using the appropriate stress gradients in the weight function, then delta K is calculated as the difference between the two.

5. Crack Growth Predictions

- a. Describe the material model approach used for the crack growth predictions (NASGRO, tabular, etc.) and the assumptions/approach used for “threshold”, stress ratio (R) shift, and negative R behavior.

This was defined and there were no changes other than formatting for Nasgro and converting the Kmax for negative R into delta K.

- b. What growth increment was utilized between stress intensity calculations?

0.01 inch.

6. Provide any additional details that may be pertinent to the analyses completed

This was a fairly straight forward analysis that could be performed in a couple of hours which would make it ideal for supporting 107s and 202s. Unfortunately, this method would be difficult to use with spectrum loading since a different stress gradients would be needed for each loading condition.

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