Interference Fit Fastener Prediction Challenge

QUESTIONNAIRE

Contact Name: KC-46 Pegasus

Collaborators:

Name:

Organization:

Name:

Organization:

Please provide information about the analyses completed: BAMF 8.0 alpha was used to perform this analysis. This version has a Karray method intended for solving interference and non-linear stress intensity problems.

1. Analysis Software (name and version)
    a. FEA software (if applicable): Stress Check 10.5
    b. Crack growth software: AFGROW 5.3.5.24

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

    A half symmetry model was utilized with symmetry conditions placed on the crack plane. Interference was utilized with contact. Contact iterations were set to 14 in stress check. A max and min applied load was applied to the model via crack face traction and rigid body motion was attained by fixing the piece with constraints at the grips.

    b. Describe the methods to define and control the crack front shape and control meshing along the crack front
    BAMF defaults were utilized to define the meshing along the crack front. The crack front was defined with 21 points so ~26 elements are utilized along the crack front with a 2 layer BL refinement.
3. Interference Fit Modeling
    a. Describe the methods used to characterize and incorporate the effect of the IFF.
    IFF was incorporated through a contact solution in Stress Check. Contact iterations were set to 14 and modulus for the fastener was 30000ksi and v=0.3.

Solutions were solved for the Max and Min to get a Kmax and Kmin for AFGROW. And a contact constant of 1.0400e+06

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? Closed form solutions are lame

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 Solution uses Material Non-linearity assumption with contact iterations set to 14. Technique used was Deformation. No friction was utilized.

4. Stress Intensity Calculations
    a. Describe the methods used to extract and calculate the stress intensities for applied remote loads. BAMF was used to extract stress intensities utilizing Stress Check. Stress Check uses the contour integral method.

    b. Describe the methods used to incorporate the stress intensities into the crack growth code (superposition, etc.). A new feature was implemented into AFGROW that allows an array of K's at different stresses. This allows for calculations of non-linear (or non-zero at no applied stress) stress intensities. AFGROW uses this array to calculate K min and Kmax and deltaK.
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.

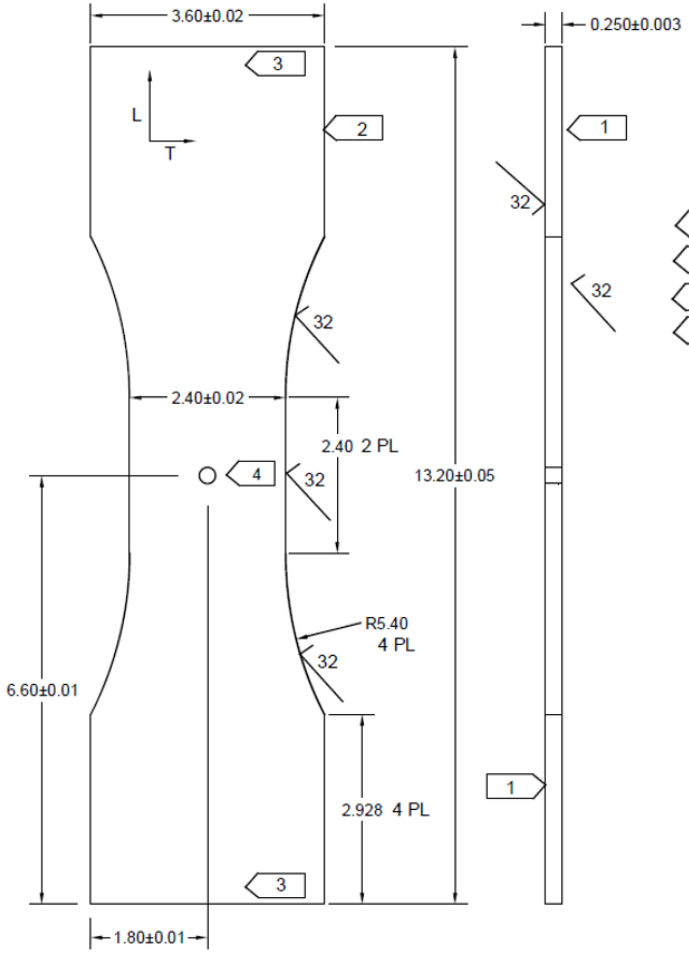
A tabular lookup file was utilized. Threshold was set to 2.18462 at R=0. Lower limit on R shift -0.15 upper limit of 0.85.

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

Vroman crack growth increment of 3% was used. Once a single point in the model reaches 3% of its previous length new betas are calculated.

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

APPENDIX B
COUPON GEOMETRIES



Dimensions in inches unless otherwise noted.

Stock thickness is approximately 0.250 inch. Use as-is.

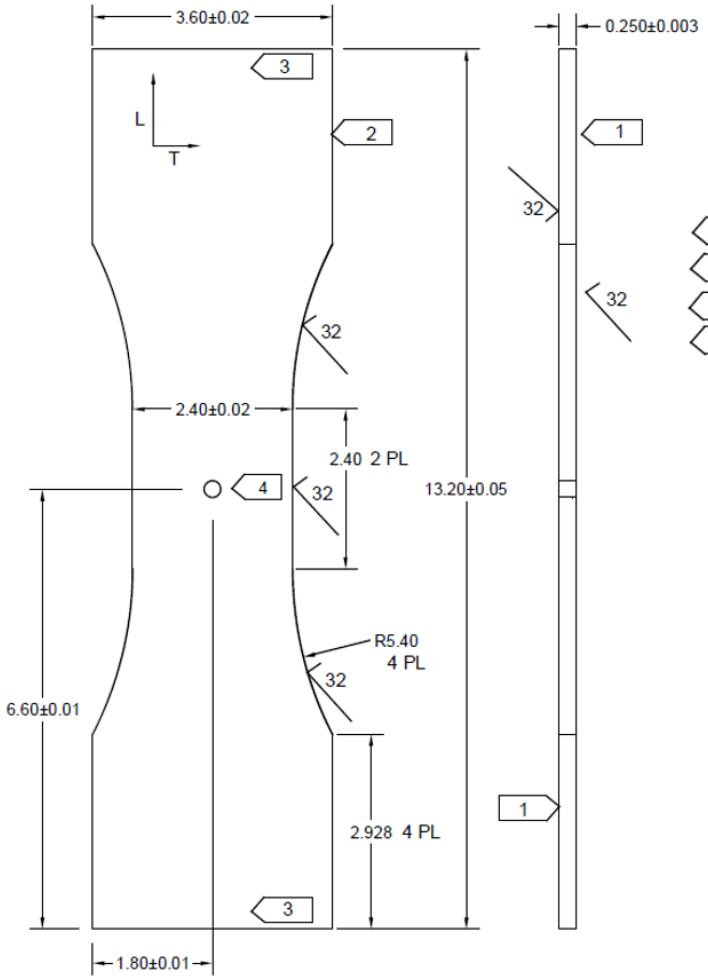
1. Hand sand with emery cloth in longitudinal direction (each face) to remove mill scale
2. Last 0.020" removal on edges must be done in 0.005" passes.
3. Specimen ID will be engraving in format 7D3-xx-Da-2480, with xx ranging sequentially from 13 to 28
4. Hole preparation (drill & reamer entry face are on Specimen ID side)

A. Initial drill using FTI CBSD-8-0-N-1 (approx. 0.216" diameter)
B. Initial ream using FTI CBSR-8-0-N-1 (approx. 0.2355" diameter. Tolerance is +/- 0.0005)
C. Manually deburr hole without radiusing or chamfering edge.
D. Record straight bore hole diameter to X.XXXX precision
E. Holes will require final ream to 0.25 inch +/- 0.0005
F. Deburr front and back side of hole using supplied Cogsdill Burraway Tool or similar method
G. Corner break on label face should be 0.025 inch + 0.005 / - 0.000 inch (radius or chamfer)
H. Corner break on opposite face should have corner break not exceeding 0.005 inch.

Material: 7075-T651 AL	QTY: 16	Condition: Type A CX	Finish: 64 RMS unless noted

Figure 2. Benchmark Condition 1 Geometry (Precracked at initial ream, final ream after precrack and removing notch)

Interference Fit Fastener Prediction Challenge



Dimensions in inches unless otherwise noted.

Stock thickness is approximately 0.250 inch. Use as-is.

1. Hand sand with emery cloth in longitudinal direction (each face) to remove mill scale
2. Last 0.020" removal on edges must be done in 0.005" passes.
3. Specimen ID will be engraving in format 7D3-xx-Da-2480, with xx ranging sequentially from 1 to 3
4. Hole preparation (drill & reamer entry face are on Specimen ID side)

A. Initial drill using FTI CBSD-8-0-N-1 (approx. 0.216" diameter)
B. Initial ream using FTI CBSR-8-0-N-1 (approx. 0.2355" diameter. Tolerance is +/- 0.0005)
C. Manually deburr hole without radiusing or chamfering edge.
D. Record straight bore hole diameter to X.XXXX precision
E. Holes will require final ream to 0.2480 inch +/- 0.0005
F. Deburr front and back side of hole using supplied Cogsdill Burraway Tool or similar method
G. Corner break on label face should be 0.025 inch + 0.005 / - 0.000 inch (radius or chamfer)
H. Corner break on opposite face should have corner break not exceeding 0.005 inch.

Material: 7075-T651 AL	QTY: 16	Condition: Type A CX	Finish: 64 RMS unless noted

Figure 3. Benchmark Condition 2 and 3 Geometry (Precracked at initial ream, final ream after precrack and removing notch)

APPENDIX C
MATERIAL PROPERTIES

Property	Value
Material	7075-T651 plate
Modulus (ksi)	10400
Poisson	0.33
Ultimate Strength (ksi)	83
Yield Strength (ksi)	73
Plane Stress Fracture Toughness (ksi-root(inch))	58
Plane Strain Fracture Toughness (ksi-root(inch))	27
Rlo	-0.15
Rhi	0.85

Interference Fit Fastener Prediction Challenge

da/dN	Stress Ratios (R)					
	K_{max}	ΔK				
	-0.15	0.02	0.1	0.4	0.7	0.85
1.00E-11	1.957	2.15	2.010	1.36	1.150	0.972
1.00E-10	1.995	2.175	2.045	1.39	1.220	1.071
3.00E-10	2.015	2.193	2.065	1.408	1.255	1.119
1.00E-09	2.062	2.237	2.111	1.442	1.300	1.172
2.00E-09	2.103	2.278	2.152	1.473	1.330	1.201
1.00E-08	2.233	2.400	2.280	1.562	1.400	1.255
2.00E-08	2.336	2.492	2.380	1.634	1.440	1.269
4.00E-08	2.529	2.675	2.570	1.765	1.530	1.326
6.00E-08	2.744	2.897	2.787	1.919	1.645	1.410
1.00E-07	3.302	3.485	3.354	2.322	1.965	1.663
2.00E-07	4.052	4.275	4.115	2.890	2.400	1.993
4.00E-07	4.878	5.150	4.955	3.650	2.975	2.425
6.00E-07	5.191	5.490	5.275	3.950	3.175	2.552
1.00E-06	5.477	5.825	5.575	4.225	3.360	2.672
2.00E-06	6.064	6.550	6.200	4.750	3.765	2.984
4.00E-06	7.026	7.650	7.200	5.550	4.400	3.488
6.00E-06	7.895	8.630	8.100	6.260	4.950	3.914
1.00E-05	9.419	10.339	9.675	7.510	5.875	4.596
2.00E-05	11.885	13.110	12.225	9.530	7.250	5.515
4.00E-05	15.605	17.300	16.075	12.600	8.850	6.216
1.00E-04	22.061	24.550	22.750	17.925	11.100	6.874
2.00E-04	26.617	29.700	27.470	21.725	12.500	7.192
4.00E-04	30.493	34.100	31.490	24.885	13.650	7.487
6.00E-04	32.597	36.500	33.675	26.550	14.200	7.595
8.00E-04	34.115	38.225	35.250	27.690	14.625	7.724
1.00E-03	35.231	39.500	36.410	28.500	14.900	7.790
2.00E-03	38.526	43.250	39.830	30.500	15.600	7.979
4.00E-03	42.037	47.250	43.475	31.870	16.130	8.164
1.00E-02	45.770	51.500	47.350	33.000	16.650	8.401
2.00E-02	47.313	53.250	48.950	33.5	16.875	8.500
1.00E-01	49.287	55.500	51.000	34.1	17.100	8.575