

# BAMpF Workshop 2024

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September 11

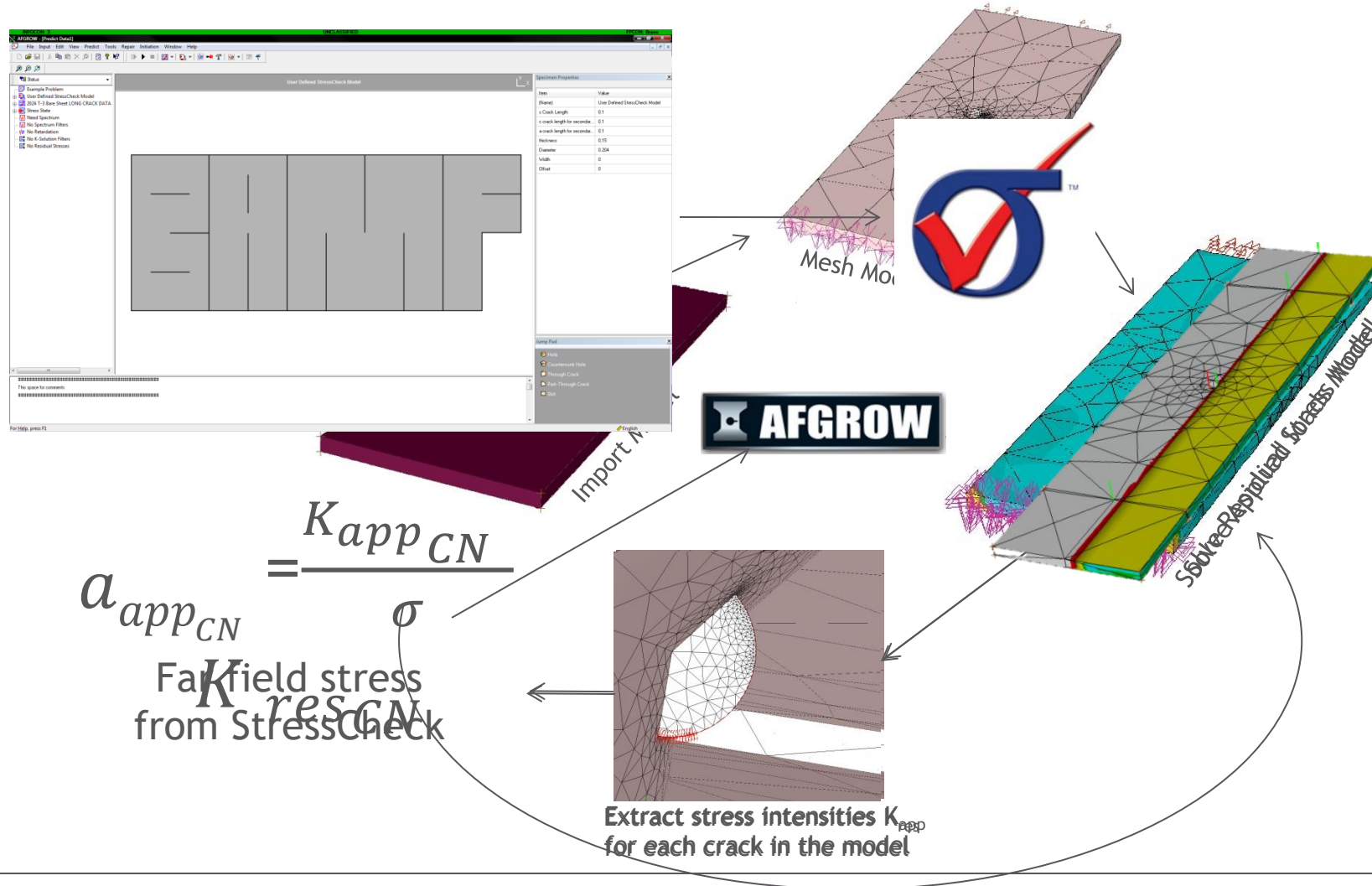
# Overview: What is BAMpF?

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Broad Application for Multi-point Fatigue

# Overview: BAMpF Process Flow



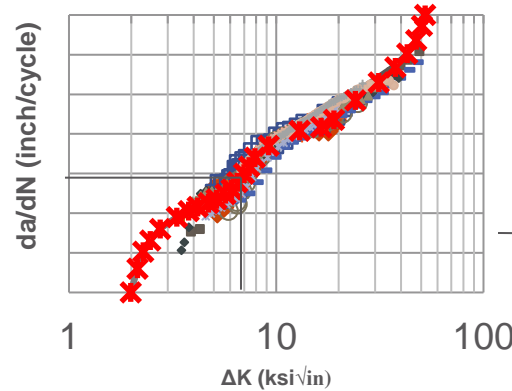
# Overview: BAMpF Process Flow

$$K_{min_{CN}} = a_{app_{CN}} \sigma_{min} + K_{res_{CN}}$$

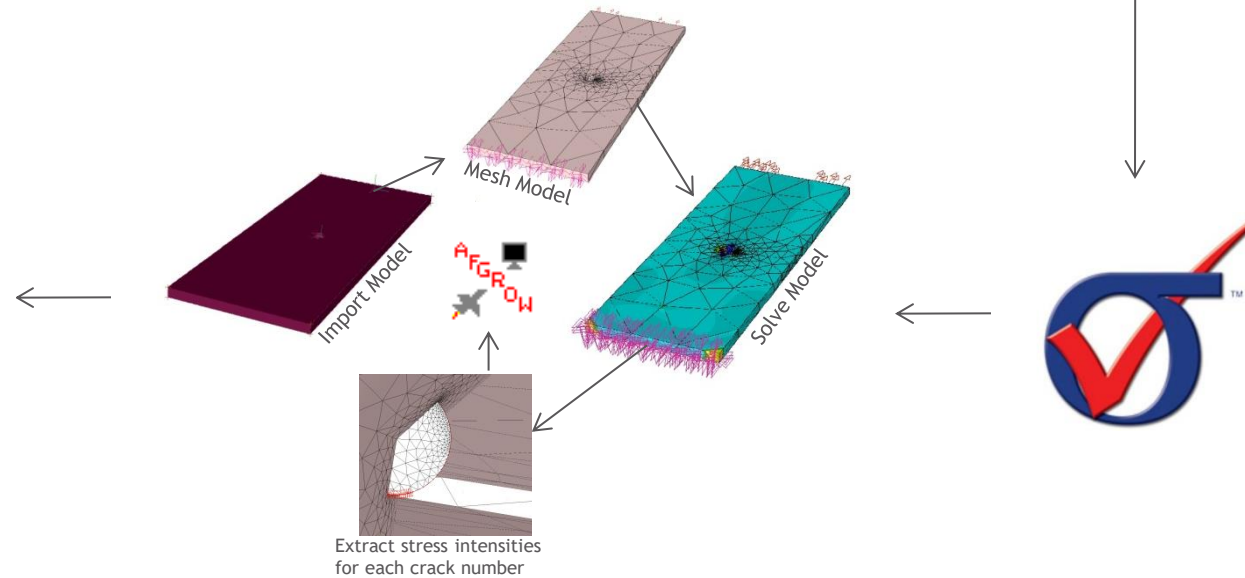
$$K_{max_{CN}} = a_{app_{CN}} \sigma_{max} + K_{res_{CN}}$$

Where  $\sigma_{min/max}$  is the AFGROW spectrum stress

$$R_{CN} = K_{min_{CN}} / K_{max_{CN}}$$



→ New Crack Lengths



# BAMpF Current State

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- ❑ Operational with releases of StressCheck™ 11.1 and AFGROW 5.4
- ❑ Beginning testing with StressCheck 12.0 (initial testing positive)
- ❑ Windows 10/64 bit compatible
- ❑ Windows 11? good luck!
- ❑ Full utilization of StressCheck™ software suite
  - Complex load cases (via sets)
  - Contact solutions
  - Residual stresses
  - Bearing loads
- ❑ Full utilization of AFGROW crack growth capabilities
  - Spectrum capabilities
  - Load interaction models (you can use them at your own risk)
- ❑ Functional API
  - Updated code with significant enhancements
  - Easy integration with in-house FCG codes
- ❑ USAF Approved Software!

Release date Winterish 2024

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## Upcoming BAMpF 8.2 FEATURES


# Features

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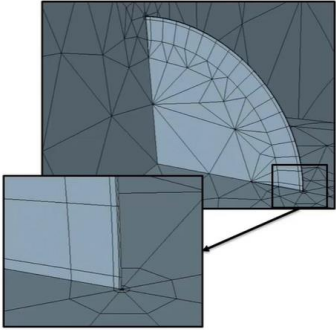
- CRACK any boundary set**
- Mesh optimization**
- Element quality checking**
- GUI Updates**
  - Crack View Update
  - Parameter Table
  - Chart Templates
- Updated Error Log/GUI Reporting**
- BAMpF Analysis Reviewer: Movie Maker**

# CRACK “any boundary” Set

- ❑ The CRACK and boundary set allows BAmP to utilize the new StressCheck (11.1) feature Crack Front meshing routine.
- ❑ This mixed mode meshing routine has been implemented in StressCheck 11.1 and utilized in BAmP 8.1
- ❑ It has been shown to increase solution accuracy while reducing solution time\*
- ❑ Stress intensities extracted with the Crack Front meshing routine are smoother and more uniform than the traditional Any Boundary meshing routine

**Upgraded Crack Front Automesh Method** 

- ❑ The existing Crack Front automesh method has been enhanced to include D/H Curvature, Mixed Mesh, Integration Layer and Grade Toward Ends options.
  - Mixed Mesh (on by default) functions the same as for the Boundary Layer method, controlling whether the mesh around the crack front is constructed entirely of tetras or a mix of pentas and hexas.
  - Integration Layer (on by default) will add an additional layer of refinement around the innermost layer for optimal fracture extractions.
  - Grade Toward Ends (off by default) will produce a geometric gradation toward either end of the selected curve.
- ❑ Crack Front method also extended to support refinement at symmetry planes.

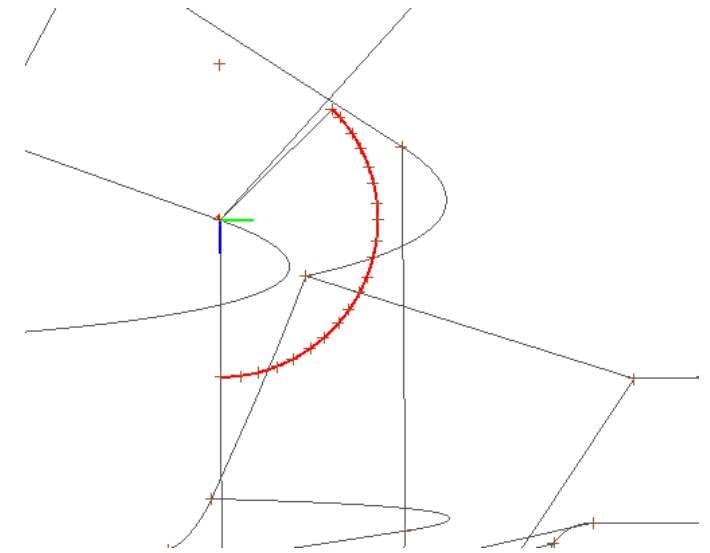
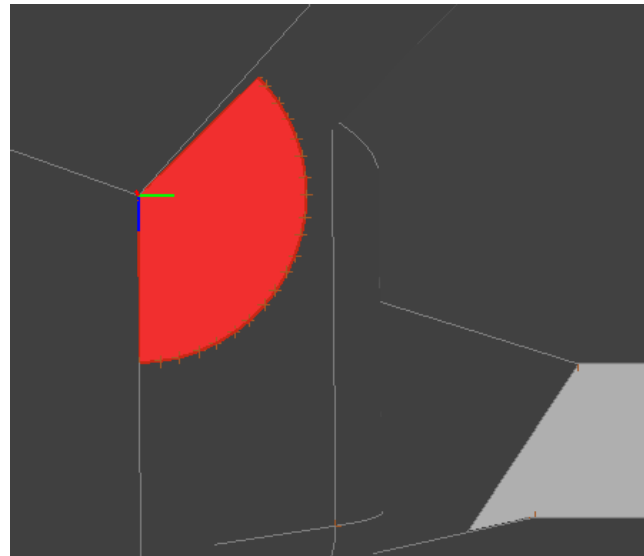
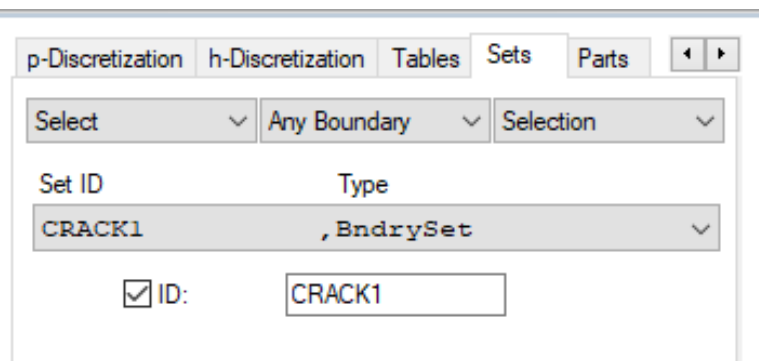


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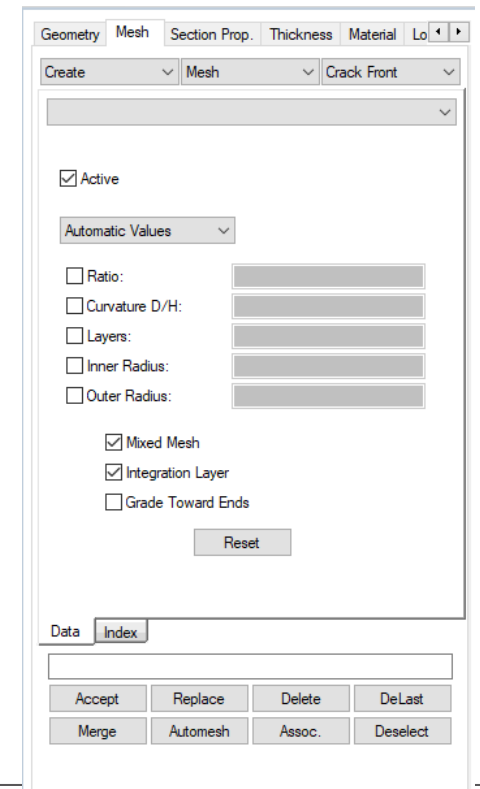
# CRACK “any boundary” Set

- ❑ To create the CRACK# set utilize any boundary selection set
- ❑ Select the crack face and ctrl+shift select the crack front
- ❑ This triggers BAmP to utilize the Crack Front meshing routine in SC
- ❑ Alternatively you can create the mesh yourself, and ignore BAmP algorithms together
  - ❑ This will stop BAmP from attempting to remesh when mesh failures occur



# Mesh Optimization

- To avoid BAMpF model failures we updated the meshing routine to include multiple attempts at meshing the model utilizing different meshing routines
- If a CRACK any boundary set is present BAMpF will utilize the CrackFront mesh option in BAMpF and utilize 7 different combinations of parameters in attempt to make a valid mesh
- If no valid mesh is created or CRACK any boundary set is not present BAMpF will utilize the classic Boundary Layer mesh routine
- BAMpF will attempt meshing the model utilizing 4 different combinations of parameters in attempt to make a valid mesh
- If no mesh created is valid BAMpF will stop the analysis





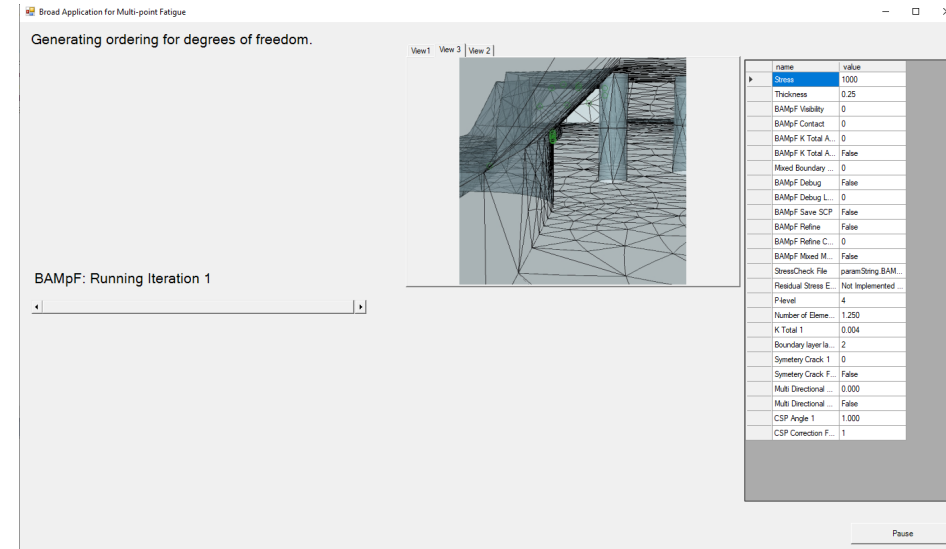
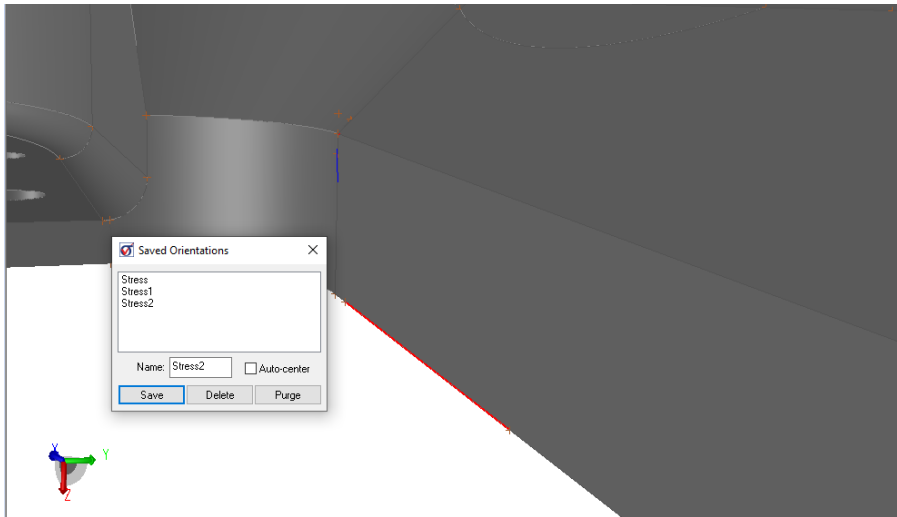
# Element Quality Check

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- MeshSim/StressCheck occasionally/semi-frequently creates visible meshes, but have an invalid element that prevents the solution from completing
- This error immediately stopped the BAMPF run as the solution could not be completed and subsequent extraction would fail
- The error was not easily identifiable by users causing pain, grief, whining, and crying to technical support
- StressCheck suggested utilizing a feature that could check element quality while creating the mesh
- If the mesh fails this check it will utilize the next mesh in the Mesh Options outlined in the previous slides
- The check adds 20-60 seconds per iteration/per mesh applied
- The check nearly eliminates the crashing of SC due to solution errors
- Expected to greatly reduce the whining

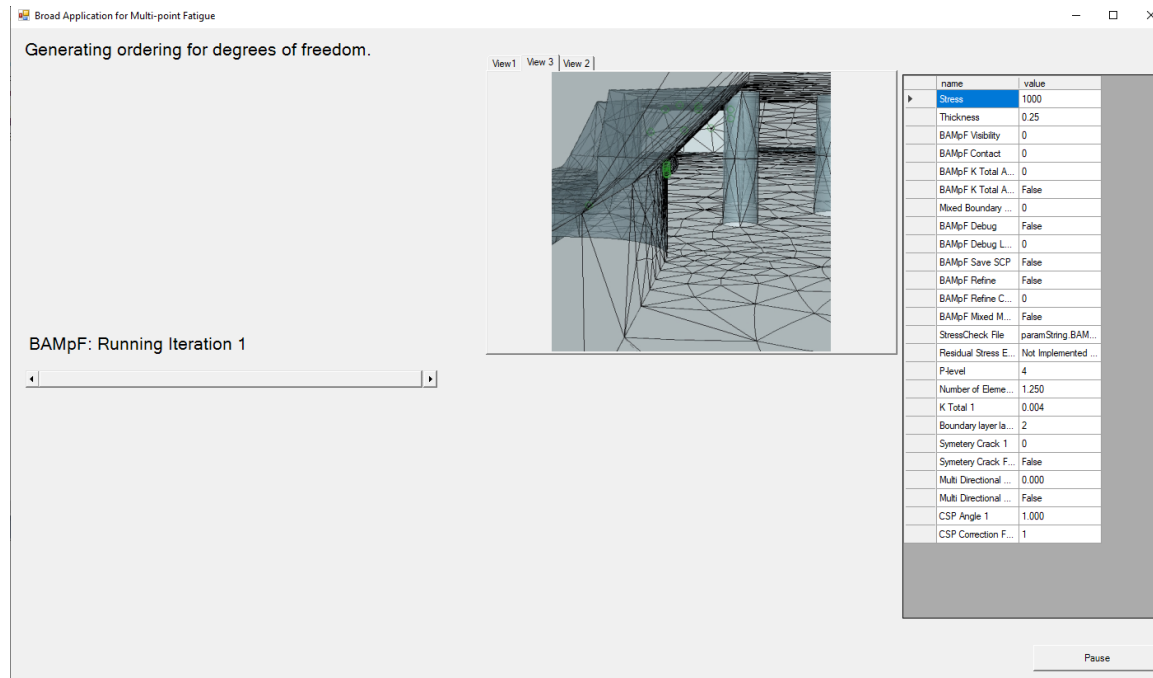
# Crack View Updates

- ❑ Users requested the option to create different views that could be utilized to make movies
- ❑ If zooming in on cracks to view details prior to reaching through thickness it is impossible to see cracks as they get longer
- ❑ BAMpF implemented the ability to store unlimited views by creating stored views indexed with the name Stress.
- ❑ Each view will be selectable via the tabs above the image in the GUI



# Table of BAMpF Parameters

- ❑ BAMpF now outputs a table of common BAMpF parameters
- ❑ Allows user to differentiate between multiple runs
- ❑ Quickly glance at parameters to ensure proper implementation
- ❑ Currently looking for workarounds to display strings for model location and RS equations

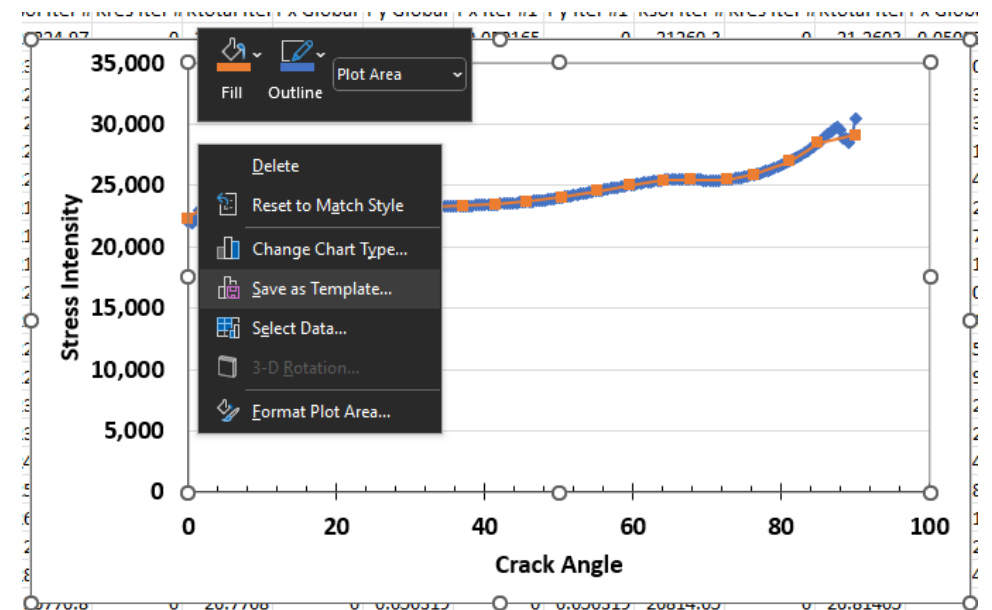
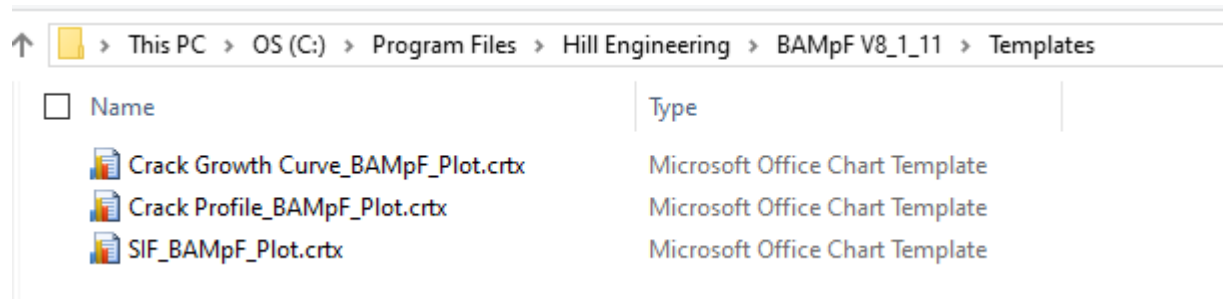


The screenshot displays the 'Broad Application for Multi-point Fatigue' software interface. The main window shows a 3D model of a mechanical part with a mesh. The status bar indicates 'Generating ordering for degrees of freedom.' and 'BAMpF: Running Iteration 1'. A table of parameters is visible on the right side of the interface.

name	value
Stress	1000
Thickness	0.25
BAMpF Visibility	0
BAMpF Contact	0
BAMpF K Total A...	0
BAMpF K Total A...	False
Mixed Boundary ...	0
BAMpF Debug	False
BAMpF Debug L...	0
BAMpF Save SCP	False
BAMpF Refine	False
BAMpF Refine C...	0
BAMpF Mixed M...	False
StressCheck File	paramString BAM...
Residual Stress E...	Not Implemented ...
Plevel	4
Number of Eleme...	1.250
K Total 1	0.004
Boundary layer la...	2
Symetry Crack 1	0
Symetry Crack F...	False
Multi Directional ...	0.000
Multi Directional ...	False
CSP Angle 1	1.000
CSP Correction F...	1

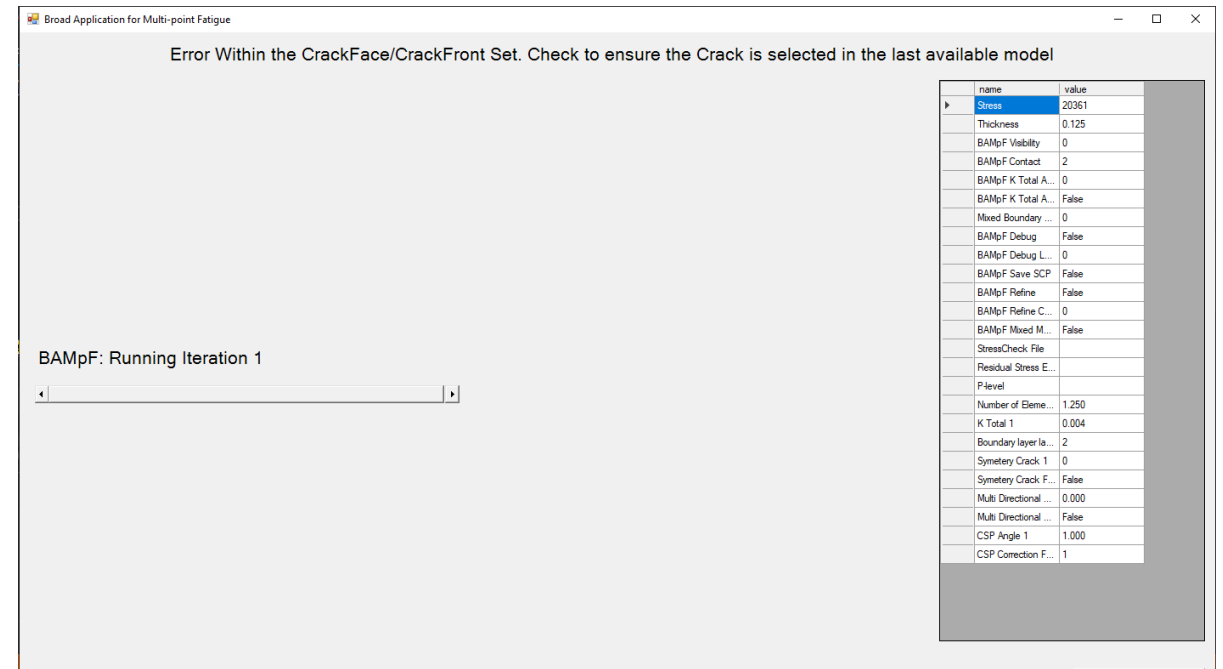
# Chart Templates

- ❑ Chart templates can be generated to make the user experience “better”
- ❑ Templates can be dropped in the BAmP program subfolder templates
- ❑ When creating a template utilize a BAmP Excel output, modify chart to your liking and delete all the series, save the template with the appropriate name
- ❑ Current Templates were created by the Lazy Jake Warner, all complaints can be sent to him



# Updated Error Log/GUI Reporting

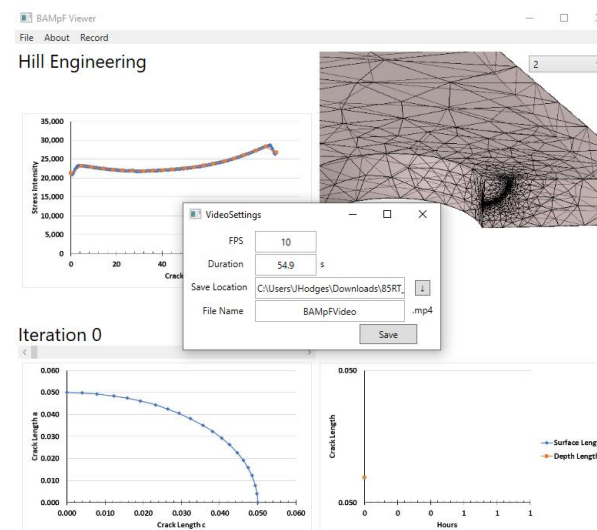
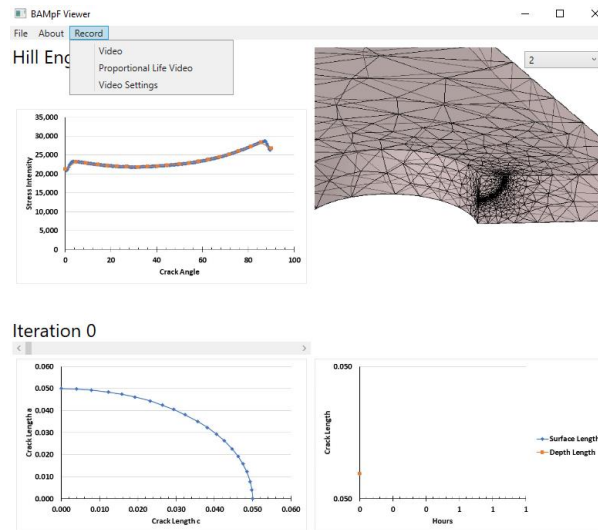
- Log files have been updated to be more specific on what error was occurring
- To determine Error see if the error reported to the main GUI
- Alternatively, go to the log file and search ERR from bottom up
- Details are provide if the error occurred in:
  - Solver
  - Meshing Routine
  - Parameter Names
  - Sets
  - Updating Parameters
  - Re-splinning the Crack





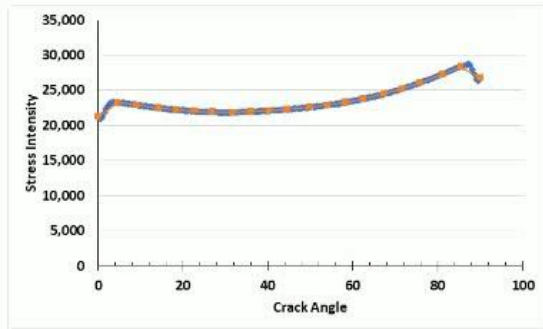
# BAMpF Analysis Reviewer Movie Maker

- ❑ BAMpF Analysis Reviewer has added capability to make beautiful videos for fantastic presentations\*
- ❑ Videos can be made to show growth proportional to the life of the part, i.e. small cracks grow slower than bigger cracks.
- ❑ Videos can be made to show each iteration for a given amount of time.
- ❑ Select the folder with the given outputs to load old BAMpF runs

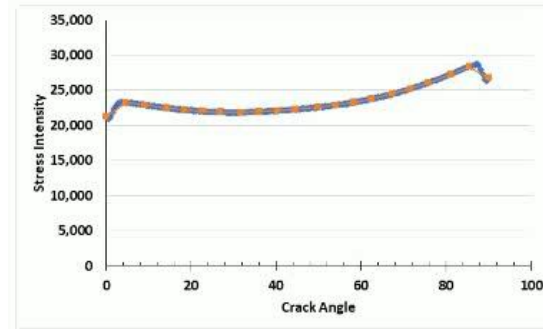


# BAMpF Analysis Reviewer Movie Maker

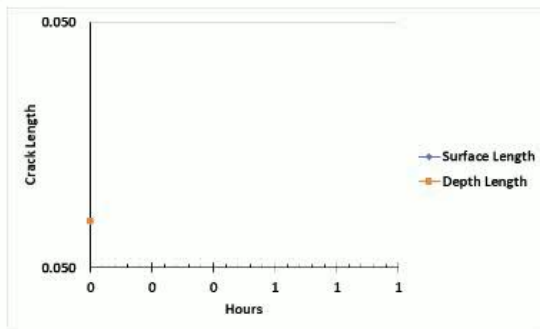
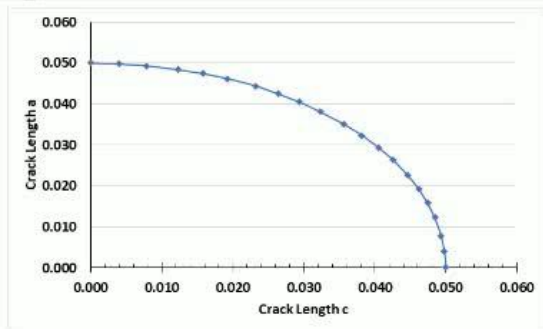
Hill Engineering



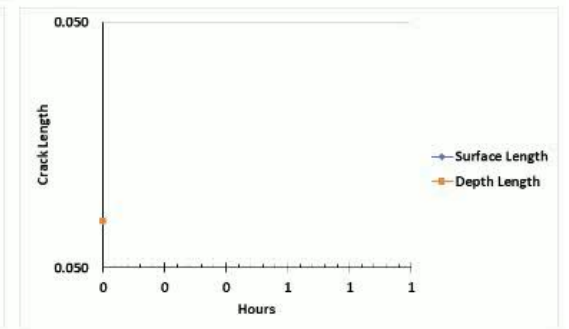
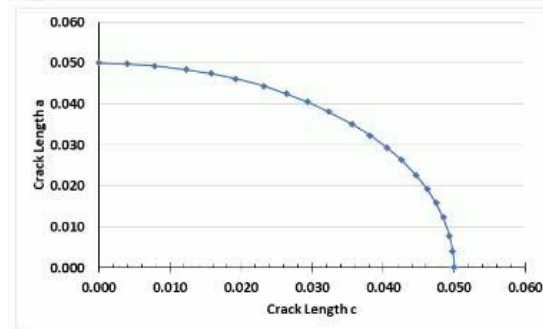
Hill Engineering



Iteration 0



Iteration 0



Sept 2023-Sept 2024

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## Reported Bugs

# BAMpF Reported Bugs

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## ❑ Saint Kaylon Anderson

- StressCheck meshing failures
- “Long” cracks get wiggly and ugly
- I can never run a model from start to finish without something stopping it

## ❑ Lazy Jake Warner

- StressCheck meshing issues
- “Long” cracks get wiggly and ugly
- Restating models do not update when updating .par file
- Restart Reports errors that cycle count doesn't exist
- Retardation has Stress State in it, How does BAMpF deal with differences through thickness?
- Retardation doesn't work at all, why are you so terrible?

## ❑ Ian Hokaj

- Model Builder doesn't work for marker bands

## ❑ Casey Scott

- StressCheck meshing issues
- “Long” cracks get wiggly and ugly

## ❑ Mike Boeke

- StressCheck meshing issues
- Restating models do not update when updating .par file
- Copying charts from a previous run to combine runs does not work any more
- Older versions of BAMpF aren't working with my updated SC/AFGROW
- Through cracks get wiggly and ugly
- My applied crack mesh is overwriting any BAMpF Meshes
- Failures due to crack reaching different points along the surface

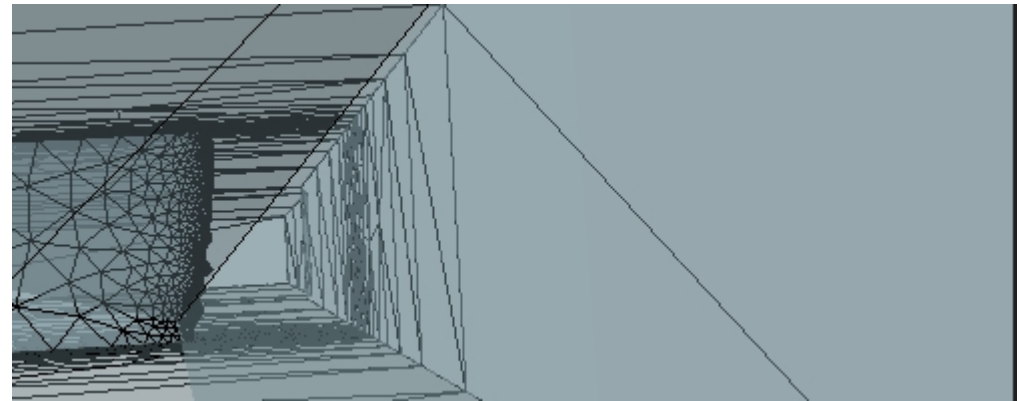
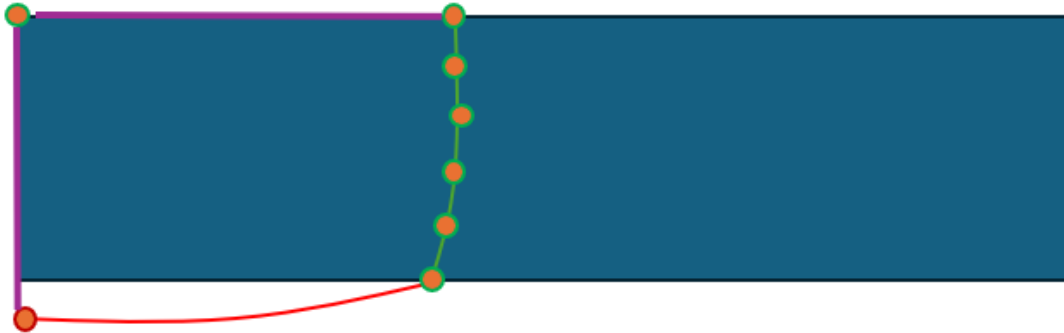
# Stress Check Meshing Issues

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- ❑ **Utilizing SC11.1 meshing issues still persisted**
  - ❑ Majority of the time, meshes were not utilizing the new Crack Front mesh in SC
  - ❑ New mesh routine still fails, investigating the cause, and the best solution
  - ❑ Sending all mixed mode mesh failures, reported to me, to SC for tracking
- ❑ **Mesh failure can be related to long through cracks that end up loosing curves in sets**
- ❑ **When Mesh failure occurs:**
  - ❑ Check start.scw file to make sure sets are selected
  - ❑ Check AfterMesh#.scw file in the output folder to review any errors that occur after meshing
    - ❑ Note if your AfterMesh# starts with 8 you are not using the new and improved meshing routine
  - ❑ Implement, if not currently using, the CRACK# any boundary set
  - ❑ Try duplicating the mesh in the AfterMesh#.scp file. Change auto meshing parameters, and add local refinements, to see if a mesh can be generated
  - ❑ Contact BAMpF Tech Support

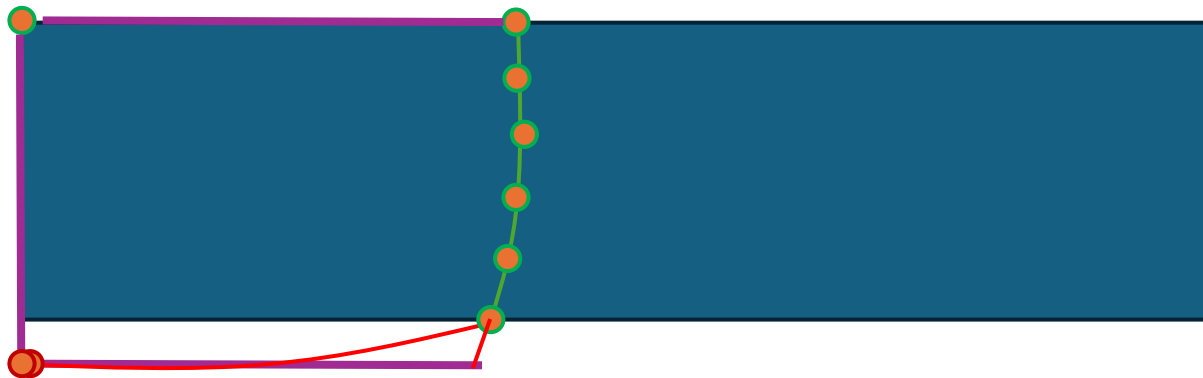
# Long Crack Modeling Issues

- ❑ Two issues exist with long cracks:
  - ❑ Modeling issue that exists when the out of body spline becomes larger than the in-body spline
  - ❑ Long cracks become unstable and crash BAmP due to failed models



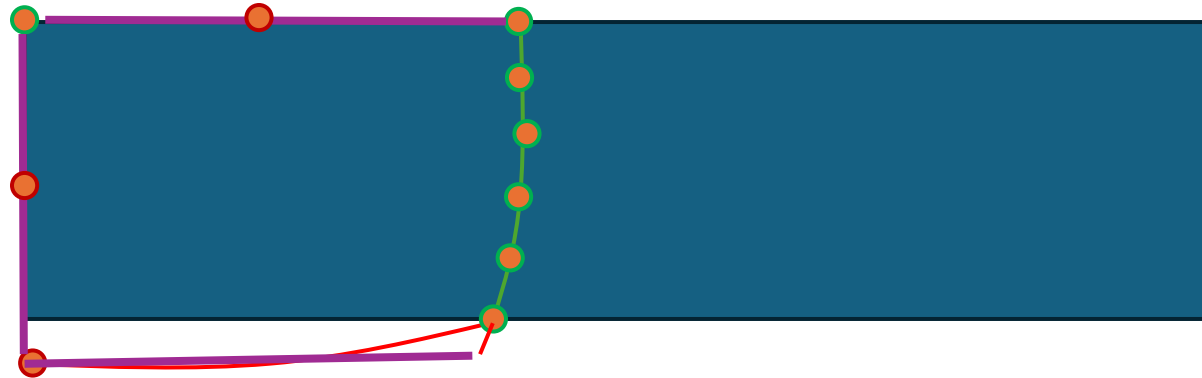
# Out of Body Spline Issues

- ❑ This common issue occurs when the out of body spline length becomes longer than the in body spline length
- ❑ SC indicates the longer length is more important in the numbering of the curves and it moves set and boundary conditions around
- ❑ Issues is not immediately evident, restarting will allow the model to run a few more iterations but will fail again without much information
- ❑ At some point the model will no longer run after restart
- ❑ The fix is “easy” but time consuming and involves deleting the current crack and rebuilding the model



# Out of Body Spline Issues

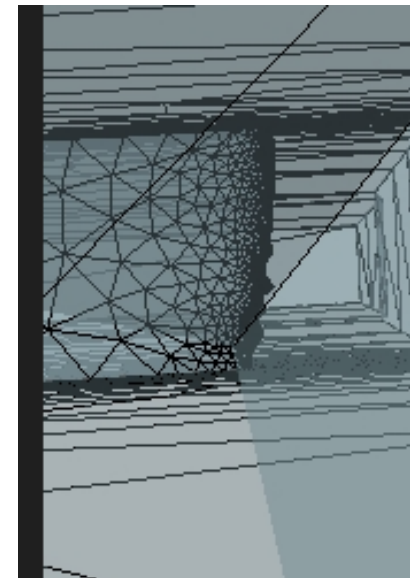
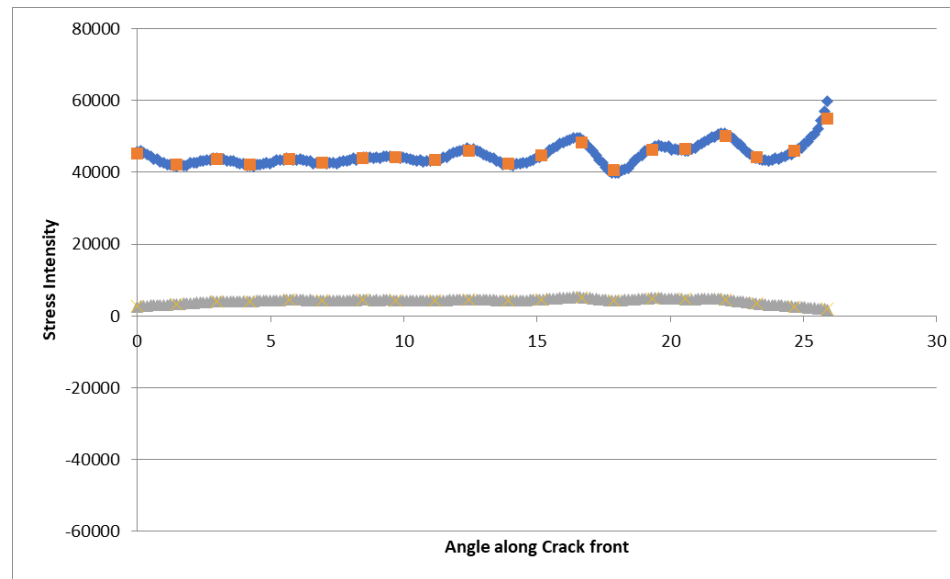
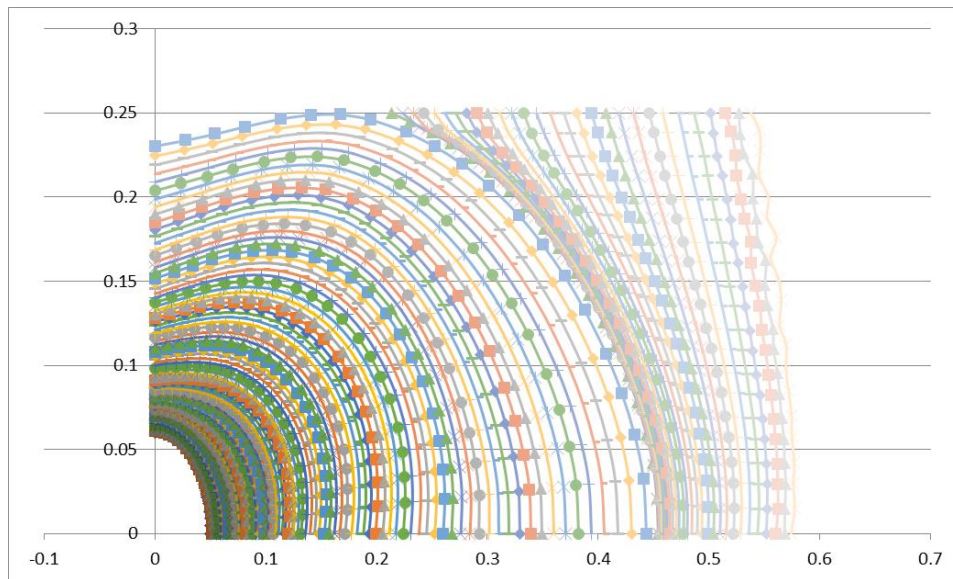
- ❑ Current recommended long term solution is to modify the way models are built
- ❑ Create intermediate points separating the 2 point lines in half
- ❑ When the point goes outside the bounds of the model, BAMpF will shift the points as shown
- ❑ Unknown how this will affect boundary conditions and sets





# Unstable Long Crack Growth

- ❑ Frequently when the crack is below critical long cracks will become unstable and crash during meshing
- ❑ Small perturbations in the  $dK$  when the crack is large makes for large differences between points. Oscillations start to occur that the model cannot rebound from
- ❑ Restarting the analysis prior to instability with a reduced growth rate is a work around
- ❑ Unknown current approach to fix the problem



# Restarting Analysis

- ❑ Error on restarting: Referencing a cycle number doesn't exist in the current spectrum
  - ❑ Error has been patched in next release, beta versions available
  - ❑ Restart analysis from the start.scp file and combine the analysis post processing
- ❑ Updates made to .par file are not getting transferred to the restart
  - ❑ Legacy versions of BAMpF utilized the .par file to modify crack shape parameters
  - ❑ With the restructuring of BAMpF the updates to the crack parameters need to be done in the excel file you want to restart from updates are done in the Cycles/Life Table starting in col J

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
3	2712.187	0.123854	0.560629	0.001212	7.42E-20	2	1.478287	3296.535	8	0.049831	0.004943	-12072	0.051331	0.005035	-11849.6	0.052783	0.005137	-11999.7	0.054371	0.00524	-11940.7	0.055918	0.005352	-12073.6	
4	2780.784	0.247612	0.560866	0.002424	1.48E-19	3	2.972393	4015.396	8	0.049429	0.009045	-11930.1	0.050882	0.009209	-11861.7	0.052401	0.009402	-11811.3	0.053932	0.009589	-11874.2	0.055528	0.009796	-11828.8	
5	2854.605	0.371283	0.561099	0.003636	-8.9E-16	4	4.216121	4175.708	8	0.048791	0.013117	-11796.9	0.050167	0.013346	-11795.3	0.051666	0.013619	-11758.7	0.053119	0.013896	-11740	0.054738	0.014187	-11761.5	
6	2906.944	0.494901	0.561324	0.004849	-8.9E-16	5	5.707867	4456.153	8	0.047712	0.017943	-11706.4	0.049216	0.017435	-11753.1	0.050423	0.018606	-11718.5	0.052138	0.018138	-11717.5	0.053667	0.018518	-11683.5	
7	2954.737	0.618498	0.561538	0.006062	3.71E-19	6	6.953289	4387.476	8	0.046551	0.021898	-11701.6	0.047778	0.022263	-11713.5	0.049115	0.022683	-11732	0.050524	0.023128	-11728.7	0.051966	0.023594	-11741.8	
8	3023.797	0.742055	0.56174	0.007276	-8.9E-16	7	8.445772	4449.701	8	0.045151	0.025774	-11717.8	0.046303	0.026194	-11740.5	0.047558	0.026672	-11762.6	0.048884	0.027179	-11790.2	0.05025	0.027712	-11805.4	
9	3059.791	0.865638	0.561926	0.00849	5.2E-19	8	9.692395	4435.19	8	0.043512	0.029556	-11765.5	0.044581	0.030023	-11814.1	0.045751	0.030554	-11848.7	0.046993	0.031119	-11877.6	0.048274	0.031712	-11905.8	
10	3113.489	0.989251	0.562094	0.009706	5.94E-19	9	11.1896	4354.711	8	0.04123	0.033943	-11885.2	0.042196	0.034466	-11945.9	0.043257	0.035046	-11998.2	0.044392	0.035673	-12033.6	0.045562	0.036328	-12075.4	
11	3143.342	1.112949	0.562242	0.010923	1.78E-15	10	12.43682	4626.396	8	0.039064	0.03745	-12018	0.039945	0.038004	-12092	0.040911	0.038628	-12164.3	0.041948	0.039296	-12220.7	0.043021	0.039995	-12273.5	
12	3216.257	1.236728	0.562366	0.012141	-8.9E-16	11	13.92848	4364.281	8	0.036661	0.040799	-12187	0.03746	0.041388	-12268	0.038329	0.042045	-12364.2	0.039264	0.042745	-12449.3	0.040237	0.043481	-12508	
13	3257.868	1.360636	0.562465	0.01336	8.18E-19	12	15.16905	4658.49	8	0.034024	0.043966	-12383.6	0.037444	0.04459	-12471.3	0.035527	0.045282	-12576.3	0.036363	0.046014	-12689.6	0.037223	0.04677	-12783.1	
14	3309.062	1.484748	0.562535	0.014581	8.93E-19	13	16.67	5114.156	8	0.030556	0.047492	-12650.9	0.031882	0.048152	-12746.3	0.031863	0.048885	-12853.6	0.032588	0.049654	-12962.9	0.033335	0.05045	-13089.7	
15	3397.314	1.609015	0.562576	0.015803	9.68E-19	14	17.87369	4420.449	8	0.027423	0.050517	-12931.8	0.027968	0.050853	-13046.7	0.028561	0.05161	-13170.8	0.029193	0.052407	-13300.7	0.029845	0.05323	-13416.2	
16	3436.602	1.734475	0.56259	0.017026	-8.9E-16	15	19.34422	4922.138	9	0.024082	0.052582	-13237	0.024547	0.053286	-13349.1	0.025054	0.054066	-13490.3	0.025595	0.054887	-13623.5	0.026153	0.055734	-13765	
17	3498.345	1.858161	0.562582	0.018252	1.12E-18	16	20.57994	4721.96	8	0.020546	0.0547	-13565.6	0.020934	0.055424	-13713.8	0.021356	0.056224	-13872.5	0.021806	0.057066	-14021.1	0.022271	0.057933	-14173.6	
18	3599.231	1.982992	0.562554	0.019478	1.19E-18	17	22.06772	4536.556	8	0.016076	0.056814	-14055.9	0.016372	0.057561	-14213.9	0.016695	0.058387	-14388.5	0.017039	0.059252	-14569.3	0.017396	0.060144	-14745.3	
19	3657.936	2.107999	0.562511	0.020705	-8.9E-16	18	23.23297	4459.407	8	0.012191	0.058189	-14532	0.012413	0.05896	-14711.5	0.012656	0.05991	-14899.5	0.012916	0.060701	-15069	0.013183	0.061614	-15263.6	
20	3716.543	2.231315	0.562457	0.021933	1.34E-18	19	24.67149	2618.937	9	0.008192	0.059188	-15127.3	0.008343	0.059991	-15295.9	0.008508	0.060872	-15463.3	0.008683	0.061788	-15656	0.008863	0.062727	-15847.4	
21	3806.917	2.353881	0.562395	0.023162	1.42E-18	20	25.90988	2033.21	5	0.004116	0.059798	-15784	0.004196	0.06064	-15867.3	0.00428	0.061551	-16008.5	0.00437	0.062493	-16161	0.004461	0.063449	-16339.4	
22	3846.863	2.483705	0.56233	0.024392	1.49E-18	21	90	-41416.5	5	-5.1E-15	0.06	-15742.3	-4.9E-15	0.060786	-16085.7	-4.9E-15	0.06166	-16372.9	-4.9E-15	0.062579	-16644	-4.7E-15	0.063524	-16843.7	
23	3913.347	2.609007	0.562265	0.025621	1.57E-18	22																			
24	3957.716	2.734493	0.562203	0.026852	-1.8E-15	23																			
25	4030.629	2.859674	0.56215	0.028083	1.78E-15	24																			
26	4062.964	2.985201	0.562108	0.029313	1.79E-18	25																			
27	4084.481	3.110448	0.562079	0.030544	1.87E-18	26																			
28	4123.814	3.235562	0.562062	0.031774	1.95E-18	27																			
29	4103.35	3.360591	0.562051	0.033004	2.02E-18	28																			
30	4132.323	3.485542	0.562044	0.034234	2.1E-18	29																			
31	4160.403	3.610365	0.562035	0.035462	2.17E-18	30																			
32	4149.426	3.735131	0.562022	0.036691	2.25E-18	31																			
33	4141.81	3.859832	0.562	0.037918	2.32E-18	32																			
34	4177.401	3.984458	0.561965	0.039143	2.4E-18	33																			
35	4143.121	4.109081	0.561914	0.040368	-8.9E-16	34																			
36	4152.791	4.233688	0.561843	0.041591	2.55E-18	35																			
37	4165.35	4.358314	0.561749	0.042813	-1.8E-15	36																			

Cycles	CIPx0	CIPy0	KRS	CIPx1	CIPy1	KRS	CIPx2	CIPy2	KRS	CIPx3	CIPy3	KRS	CIPx4	CIPy4	KRS
0	0.05	0	-11455.1	0.049429	0.009045	-12072	0.049429	0.009045	-11930.1	0.048791	0.013117	-11796.9	0.047712	0.017943	-11708.4
4416	0.051149	0	-12182	0.051331	0.005035	-11849.6	0.050882	0.009209	-11861.7	0.050167	0.013346	-11795.3	0.049216	0.017435	-11753.1
9203	0.052684	0	-12084.5	0.052783	0.005137	-11999.7	0.052401	0.009402	-11811.3	0.051666	0.013619	-11758.7	0.050423	0.018606	-11718.5
14133	0.054167	0	-12302	0.054371	0.00524	-11940.7	0.053932	0.009589	-11874.2	0.053119	0.013896	-11740	0.052138	0.018138	-11717.5
19110	0.055792	0	-12222.3	0.055918	0.005352	-12073.6	0.055528	0.009796	-11828.8	0.054738	0.014187	-11761.5	0.053667	0.018518	-11683.5
24117	0.057369	0	-12487.1	0.057901	0.005463	-12098.4	0.057139	0.009887	-11821.9	0.056367	0.014489	-11782.7	0.055237	0.018804	-11708.4

# Retardation in BAMpF

- ❑ Unexpected pinning related to retardation (BAMpF release 4/2024 and newer)
  - ❑ Model not matching AFGROW advanced model solutions
  - ❑ Rapid growth once reaching through thickness
  - ❑ Retardation parameters in BAMpF outputs do not make sense
  - ❑ da/dN and Stress Ratio values in AFGROW output do not make sense
  - ❑ Issue occurring in interpolation of retardation values during re-splining of crack front curves
  - ❑ Still investigating the cause of the issue
  - ❑ Use older version of BAMpF 11/2023, don't use retardation, or wait for patch

## Initial Retardation Parameters

length_ol	0.050039	0.049995	0.049985	0.050006	0.050037	0.050066	0.050082	0.050083	0.050071	0.050055	0.050046	0.050059	0.05008
eff_length_old	0.059415	0.062208	0.061781	0.061222	0.060791	0.060508	0.060356	0.06032	0.060392	0.060575	0.060838	0.061268	0.06179
length_old	0.050015	0.049964	0.049955	0.049977	0.050009	0.050039	0.050056	0.050057	0.050044	0.050028	0.050018	0.05003	0.05005
length_cf_old	0.052383	0.053048	0.052934	0.05281	0.052726	0.052677	0.052651	0.052643	0.052652	0.052685	0.052744	0.052861	0.053008

## Suspect Retardation Parameters

length_ol	0.071726	0.030302	2.153622	-2.27513	81.10418	-90.9488	959.3378	-629.982	-647.69	83.76629	2.315046	-2.58157	56.03963
eff_length_old	0.165463	0.653877	-24.1635	27.57449	-1179.9	1325.882	-29728.7	32818.53	2083.422	0.961175	-1.42799	1.857631	-1194.17
length_old	0.071407	0.028125	2.248634	-2.38287	85.54261	-95.9357	1086.24	-772.694	-653.567	83.92434	2.322929	-2.59093	58.81375
length_cf_old	0.09516	0.186196	-4.42565	5.187273	-234.148	263.2589	-6712.67	7732.146	35.08787	63.06501	1.379286	-1.47177	-256.512

# Retardation in BAMpF

- ❑ Wilenborg retardation has a plane strain/plane stress effect
- ❑ For AFGROW thickness is utilized for these equations
- ❑ Can we do something different for a 3d model?

$$K_{max}(eff) = K_{max} - K_{red}$$

$$K_{min}(eff) = K_{min} - K_{red}$$

$$R(eff) = K_{min}(eff)/K_{max}(eff)$$

$$K_{red} = PHI * [K_{max}(ol)(1 - (x - x(ol))/Ry(ol))^{1/2} - K_{max}]$$

$$PHI = (1 - DKThreshold/K_{max})/(SOR - 1)$$

$$Ry(ol) = (K_{max}(ol)/Yield)^2/(PSX * \pi)$$

## Where:

**x** : Crack Length

**x(ol)** : Crack Length at Overload

**DKThreshold**: Threshold value of  $\Delta K$  at  $R = 0$

**Yield** : Material yield strength

**PSX** : Stress State in a Given Crack Growth Direction (2.0 (Plane Stress) - 6.0 (Plane Strain))

$$Index = 6.7037 - 1.4972((K_{max}/Yield\ Stress)^{**2}/t)$$

If Index > 6.0, Index = 6.0 (Plane Strain)

If Index < 2.0, Index = 2.0 (Plane Stress)

# Comments



# Proposed Feature List for 2024

<u>Feature</u>	<u>Description</u>
Multi-Channel Loading	Solve for multiple loading scenarios
Integration with other FE tools	Ansys, NX
K extrapolation	Extrapolate K to radius of 0 using two different K extractions (Is this needed with new meshing routines?)
Multi-Crack Auto-Coalescence	(MCAC) When crack fronts intersect-automatically coalesce cracks
<b>3-D crack growth</b>	<b>Crack turning, out of plane crack growth</b>
Crack front splitting	When the crack front splits into multiple cracks
Custom Output files	Use a customizable .ini file to allow the user to tailor output files
<b>Retardation Tracking</b>	<b>Build the framework for appropriate Retardation tracking and restarting</b>
<b>Updated Model Creator</b>	<b>Update the model creator to work with SC10.5 and SC11</b>
<b>Restarting BAMpF in VA</b>	<b>Restart at specific cycle in the spectrum with appropriate Retardation</b>
<b>AFGROW Crashes with Dax</b>	<b>When Opening a DAX while plug-in is running AFGROW/BAMpF Crashes</b>
Failure Criteria	Implement some sort of failure criteria, beyond all points reaching K critical (Warner 2022)
<b>Long Crack Out of Body</b>	<b>When the out of body spline is large model failures occur</b>
<b>Long Crack K instability</b>	<b>When cracks are long, crack shape becomes unstable</b>

# Special Thanks

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