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AFGROW Workshop 2013

AFGROW Release 5.2

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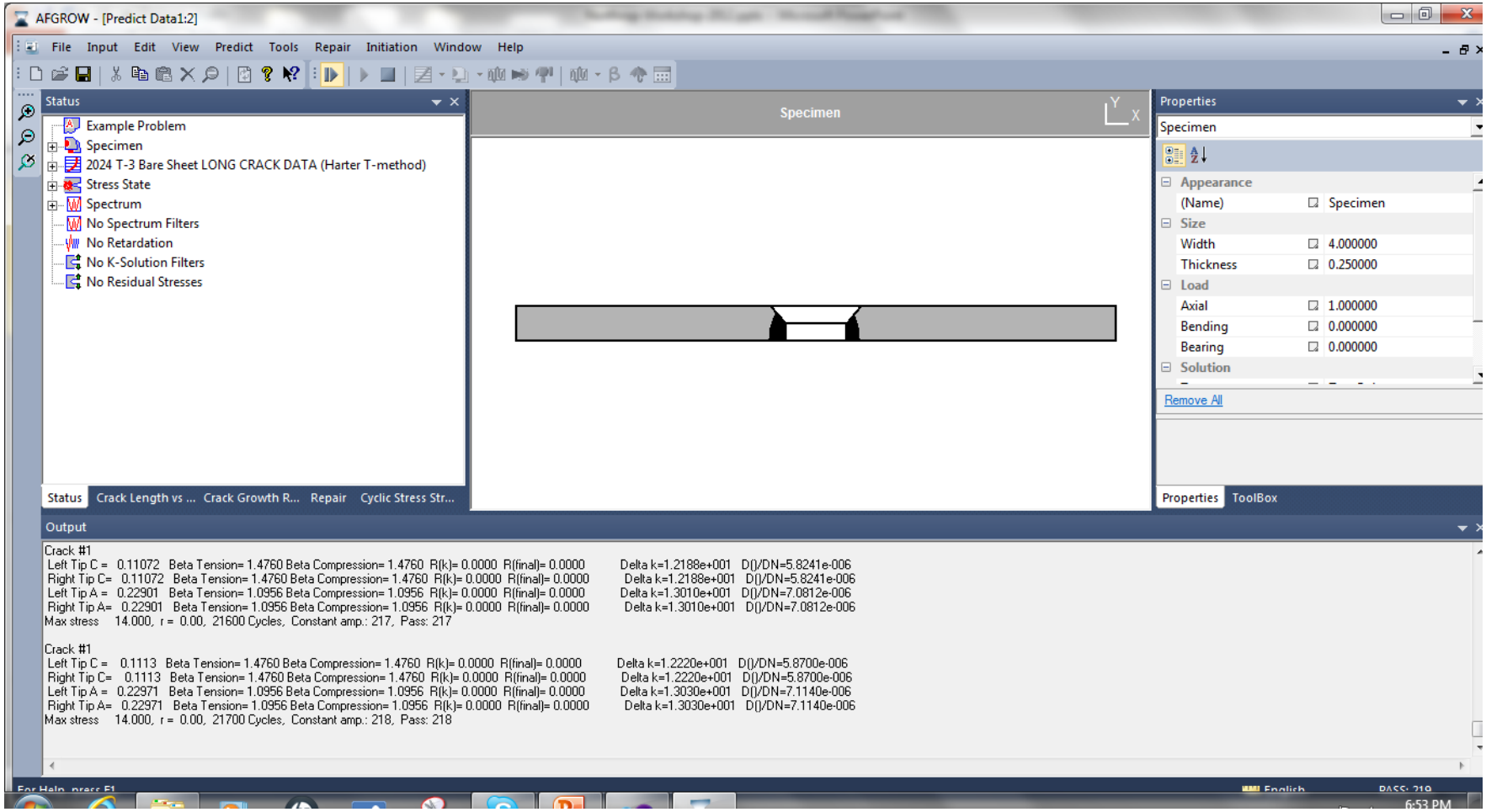
LexTech, Inc

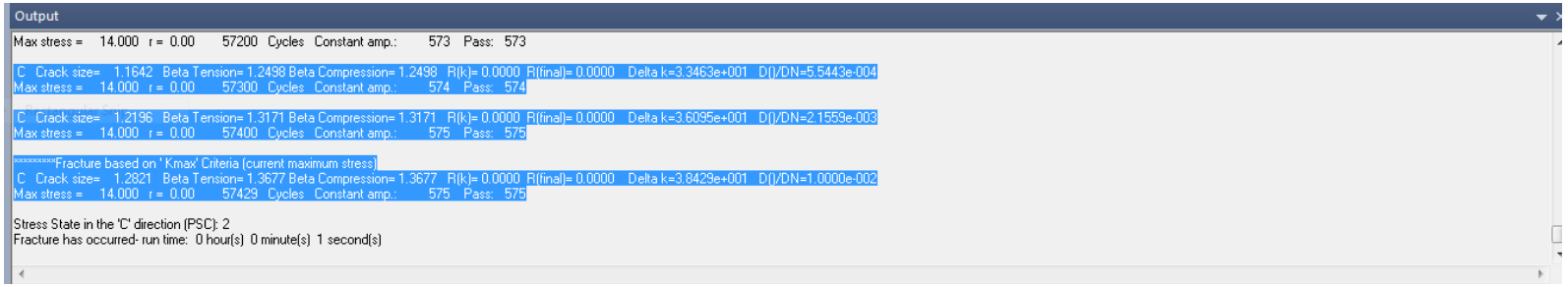
New Release

- Extended Advanced Model Solution for Corner Cracks at a Hole to Handle Small Cracks – 100%
- Updated Solution for a Single Through Crack at a Hole Under Bearing Load – 100%
- Improved Offset Correction for Cracks at Holes Under Bearing Load – 100%
- **Multi-Channel Spectrum Format – 75% - removed from the Release, will be added in the next AFROW upgrade/service pack**
- **Spectrum Tool – 90% - removed from the Release - removed from the Release, will be added in the next AFROW upgrade/service pack**
- Warning Messages When K-Solution Limits are Exceeded – 100%
- ~~Ability to Replicate Results From Previous Versions (back to Version 5.01)~~
- Expanded Input Table Size (virtually unlimited) – 100%
- ~~Option to Save Input File With Retardation State Data for Later Restart~~
- Improved COM and Plug-In Interface – 100%
- New GUI – 100%
- Corner Crack at a Countersunk Hole Solution – 90%
- Beta Sub-R – 100%
- Complete Beta Correction Capability for Advanced Models – 100%
- Fix known bugs – 90%
- Fix Beta 1 bugs – 90%
- Create new AFGROW installation – 100%

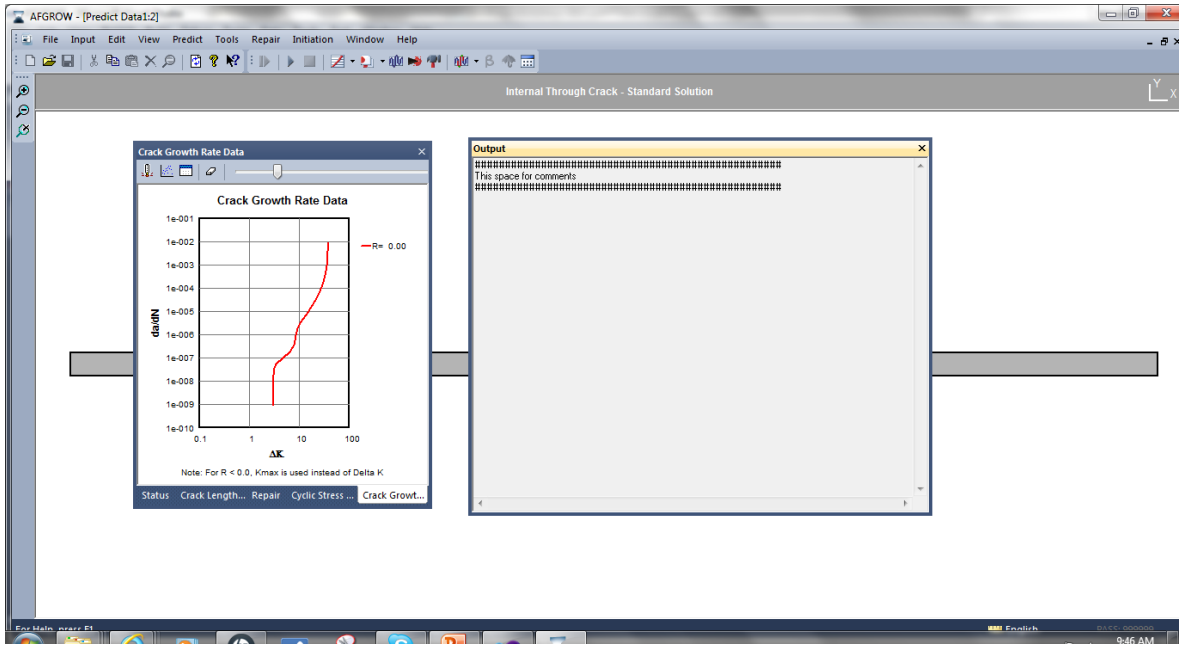
NEW GUI


AFGROW - [Predict Data1:2]
File Input Edit View Predict Tools Repair Initiation Window Help
Status
Example Problem
Specimen
2024 T-3 Bare Sheet LONG CRACK DATA (Harter T-method)
Stress State
Spectrum
No Spectrum Filters
No Retardation
No K-Solution Filters
No Residual Stresses
Status Crack Length vs ... Crack Growth R... Repair Cyclic Stress Str...
Specimen
Properties
Specimen
Appearance
(Name) Specimen
Size
Width 4.000000
Thickness 0.250000
Load
Axial 1.000000
Bending 0.000000
Bearing 0.000000
Solution
Remove All
Properties ToolBox
Output
Crack #1
Left Tip C = 0.11072 Beta Tension= 1.4760 Beta Compression= 1.4760 R(k)= 0.0000 R(final)= 0.0000 Delta k=1.2188e+001 D()/DN=5.8241e-006
Right Tip C= 0.11072 Beta Tension= 1.4760 Beta Compression= 1.4760 R(k)= 0.0000 R(final)= 0.0000 Delta k=1.2188e+001 D()/DN=5.8241e-006
Left Tip A = 0.22901 Beta Tension= 1.0956 Beta Compression= 1.0956 R(k)= 0.0000 R(final)= 0.0000 Delta k=1.3010e+001 D()/DN=7.0812e-006
Right Tip A= 0.22901 Beta Tension= 1.0956 Beta Compression= 1.0956 R(k)= 0.0000 R(final)= 0.0000 Delta k=1.3010e+001 D()/DN=7.0812e-006
Max stress 14.000, r = 0.00, 21600 Cycles, Constant amp.: 217, Pass: 217
Crack #1
Left Tip C = 0.1113 Beta Tension= 1.4760 Beta Compression= 1.4760 R(k)= 0.0000 R(final)= 0.0000 Delta k=1.2220e+001 D()/DN=5.8700e-006
Right Tip C= 0.1113 Beta Tension= 1.4760 Beta Compression= 1.4760 R(k)= 0.0000 R(final)= 0.0000 Delta k=1.2220e+001 D()/DN=5.8700e-006
Left Tip A = 0.22971 Beta Tension= 1.0956 Beta Compression= 1.0956 R(k)= 0.0000 R(final)= 0.0000 Delta k=1.3030e+001 D()/DN=7.1140e-006
Right Tip A= 0.22971 Beta Tension= 1.0956 Beta Compression= 1.0956 R(k)= 0.0000 R(final)= 0.0000 Delta k=1.3030e+001 D()/DN=7.1140e-006
Max stress 14.000, r = 0.00, 21700 Cycles, Constant amp.: 218, Pass: 218

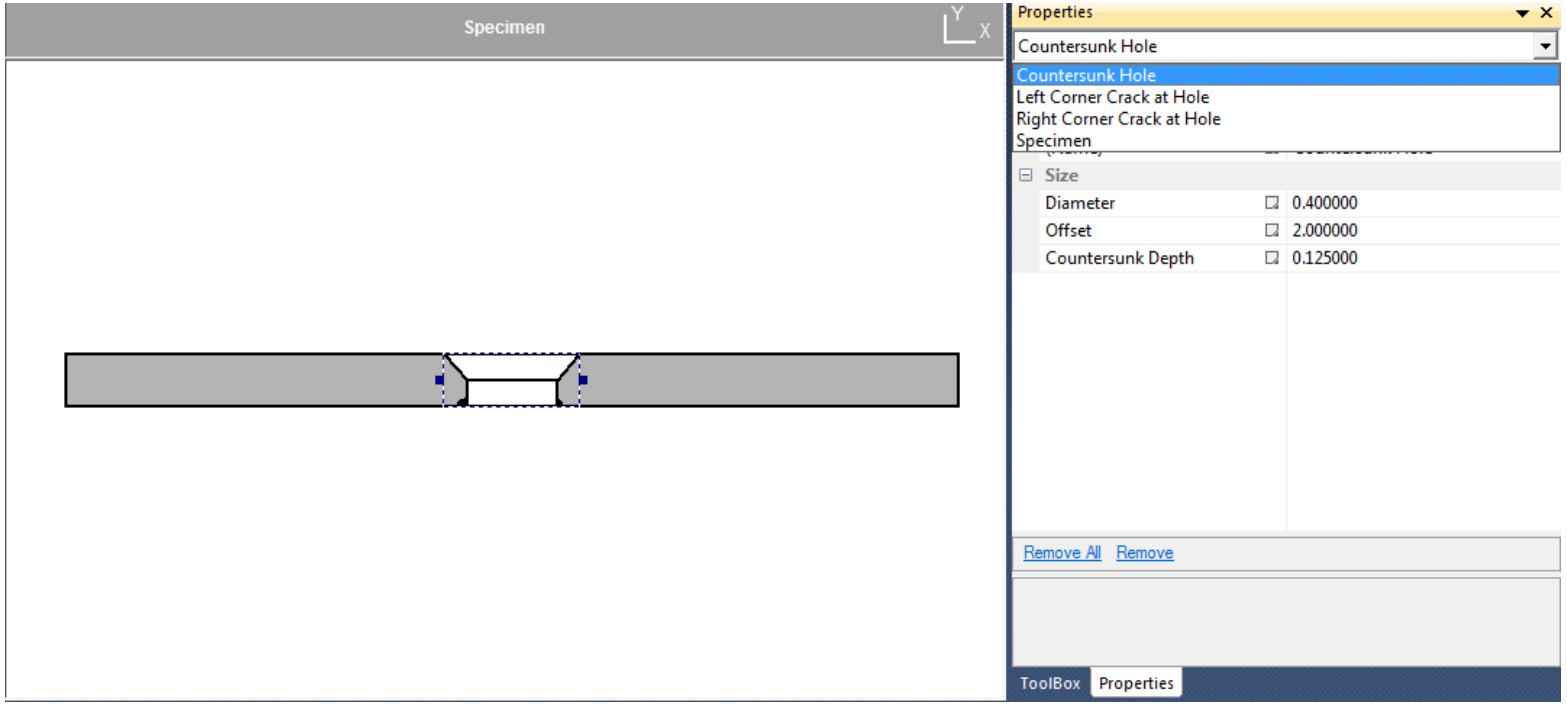
Output Frame – Copy and Paste



Floating Dockable Views



Advanced Model – Switch Objects



Advanced Model Solution Approach for Small Cracks (a/t < 0.1)

- Single Corner at a Hole

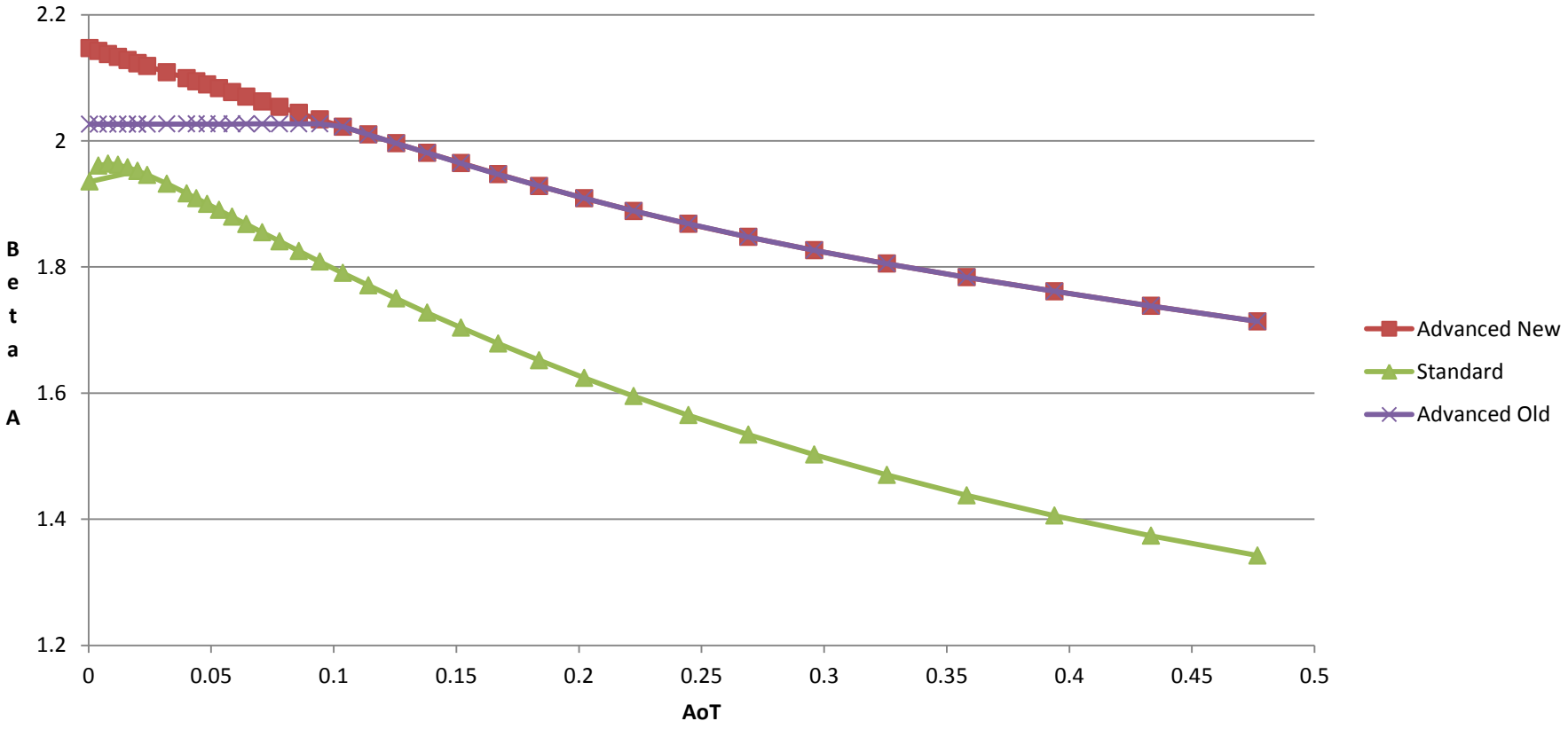
- Double Corner at a Hole

As the crack length goes to zero, the beta for both crack growth directions converge to :

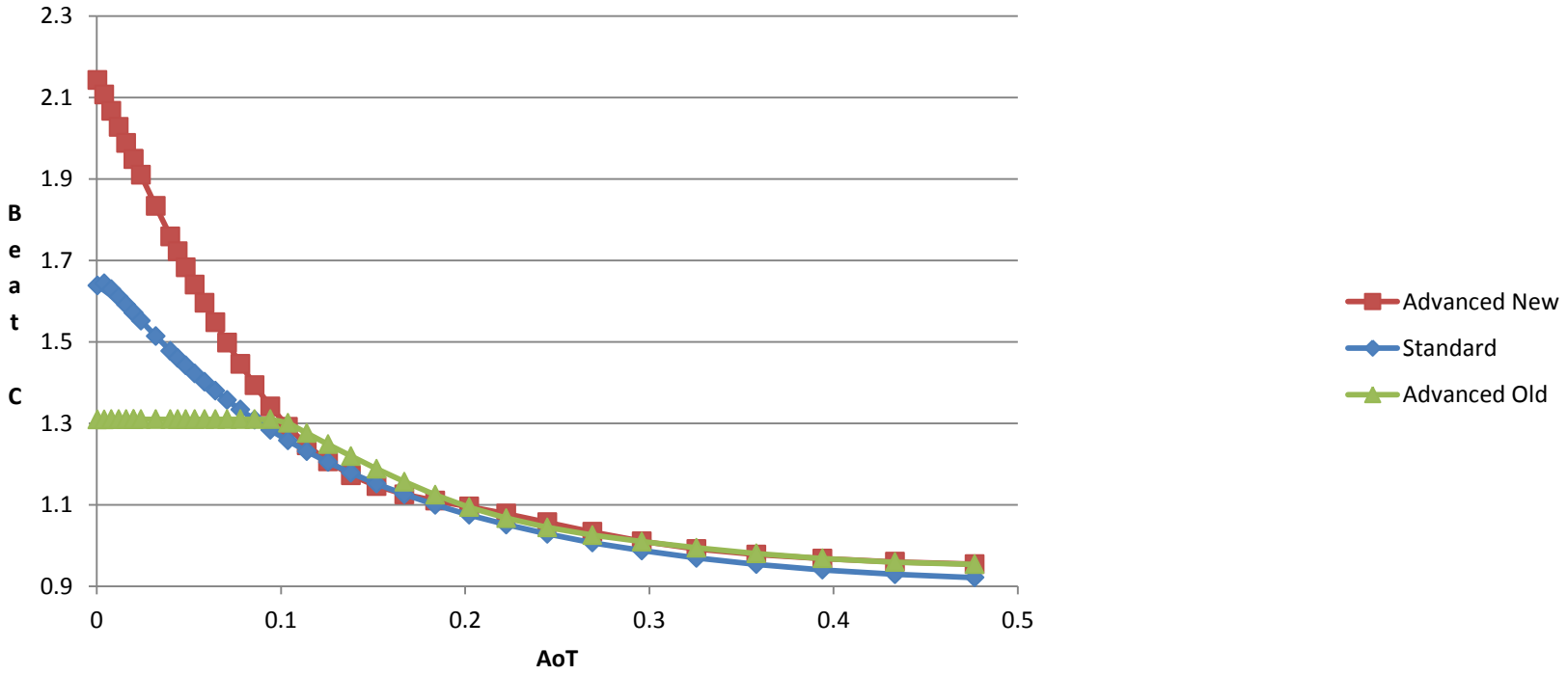
$$\beta = 1.122 \; K_t \frac{2}{\pi}$$

Tension and Bending = 2.142, Bearing = 0.625 (W/D = 100, same as Fawaz/Andersen)

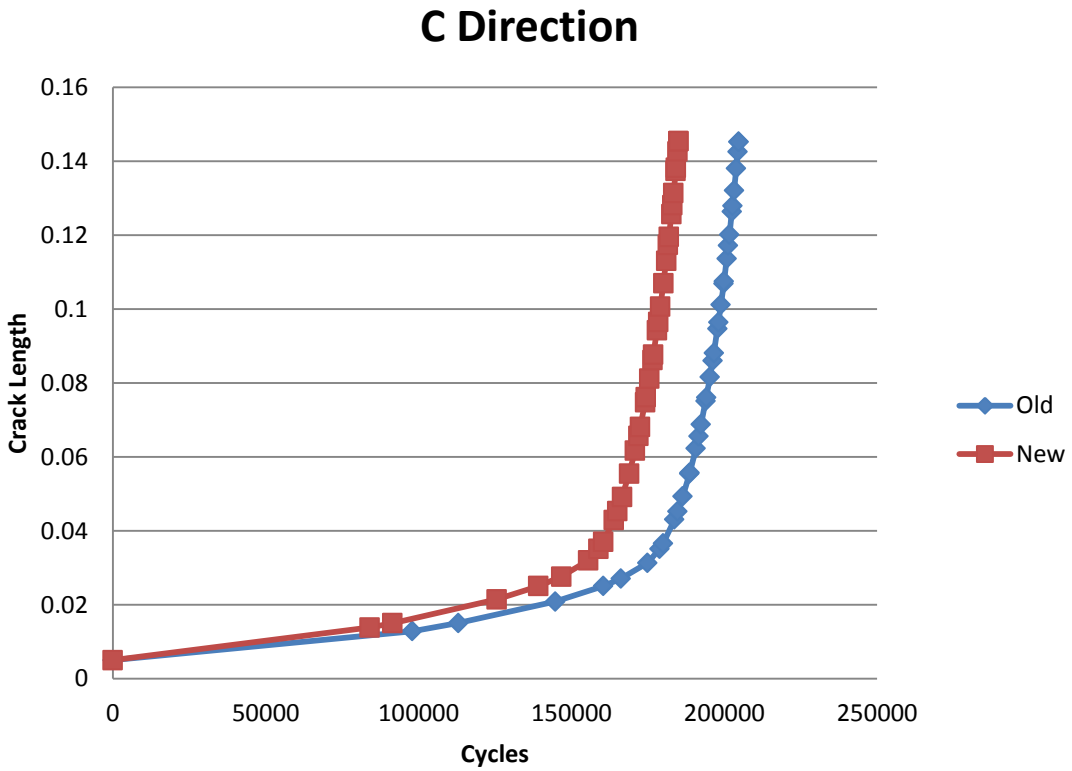
Advanced Corner Cracked Hole Model (Small Crack Beta Values)



Advanced Corner Cracked Hole Model (Small Crack Beta Values)



Advanced Corner Cracked Hole Model (Small Crack Life Comparison)

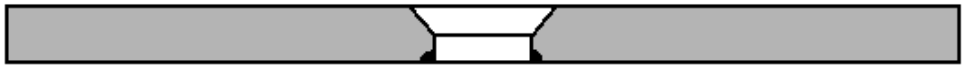


Countersunk Hole Solution

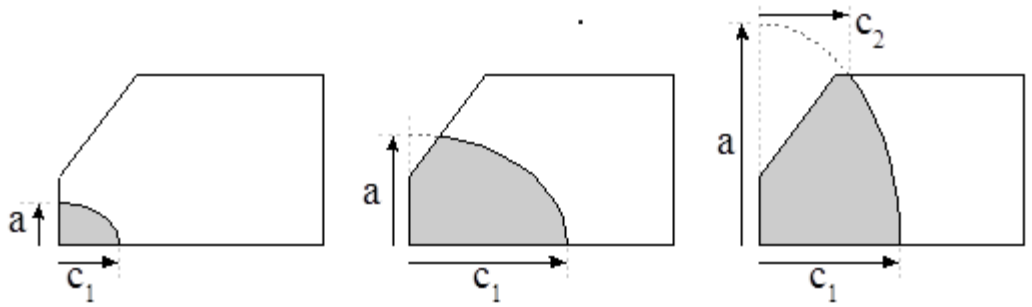
- Base on PHD thesis of the Reinier de Rijck
- Bending, Tension ad Bearing Solutions for the symmetric corner crack

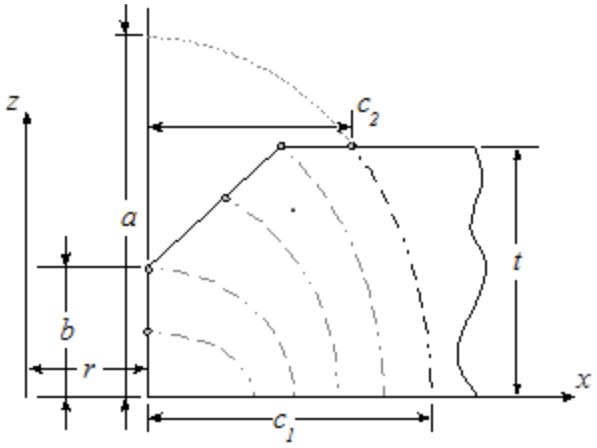
- Centered or offset hole with single corner crack

- Centered hole with symmetric double corner crack



Countersink Dimensions





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Countersunk Solution Workspace

Countersink Angle – 100 Degrees

Depth to Thickness Ratios (B/T)
0.05, 0.25, 0.5 – **Extend to 1. ?**

Virtual Crack Depth to Thickness Ratios (A/T)
0.025, 0.0294467, 0.0333167, 0.0371867, 0.0410568, 0.0449268, 0.05, 0.149025, 0.24687, 0.344714, 0.442559, 0.540403, 0.646563, 0.752822, 0.849658, 0.946494, 1.04333, 1.14017, 1.25287, 1.47261, 1.6767, 1.8808, 2.0849, 2.28899, 2.50574, …. **70.0**

Crack Depth to Crack Length Ratios (A/C)
0.5, 0.67, 0.75, 1., 1.5, 2., **5. - ?**

Hole Radius to Thickness Ratios (R/T)
0.1, 0.25, 0.5,0.67, 1.0, 1.2, 1.5, 2.0, 2.4

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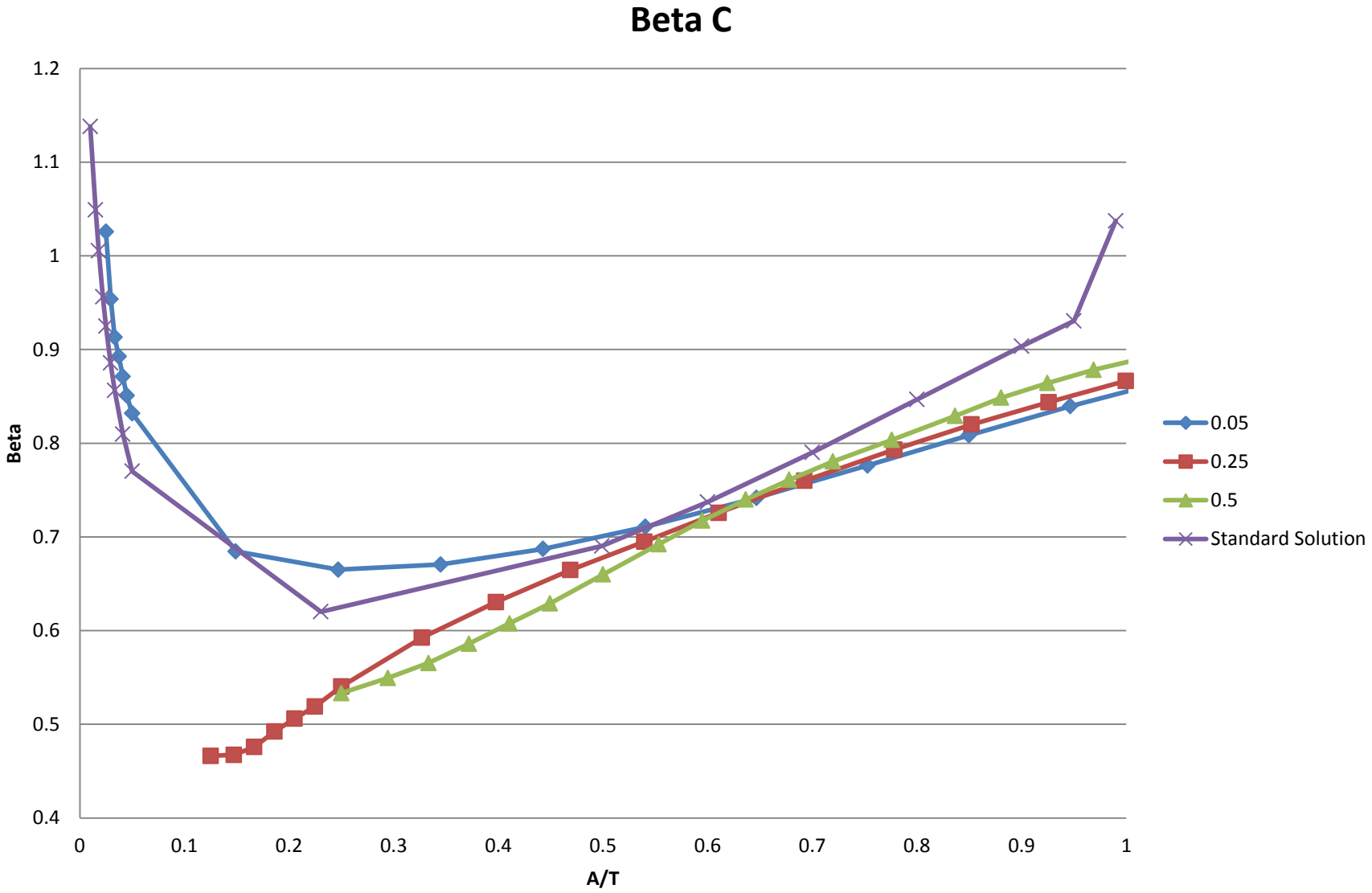
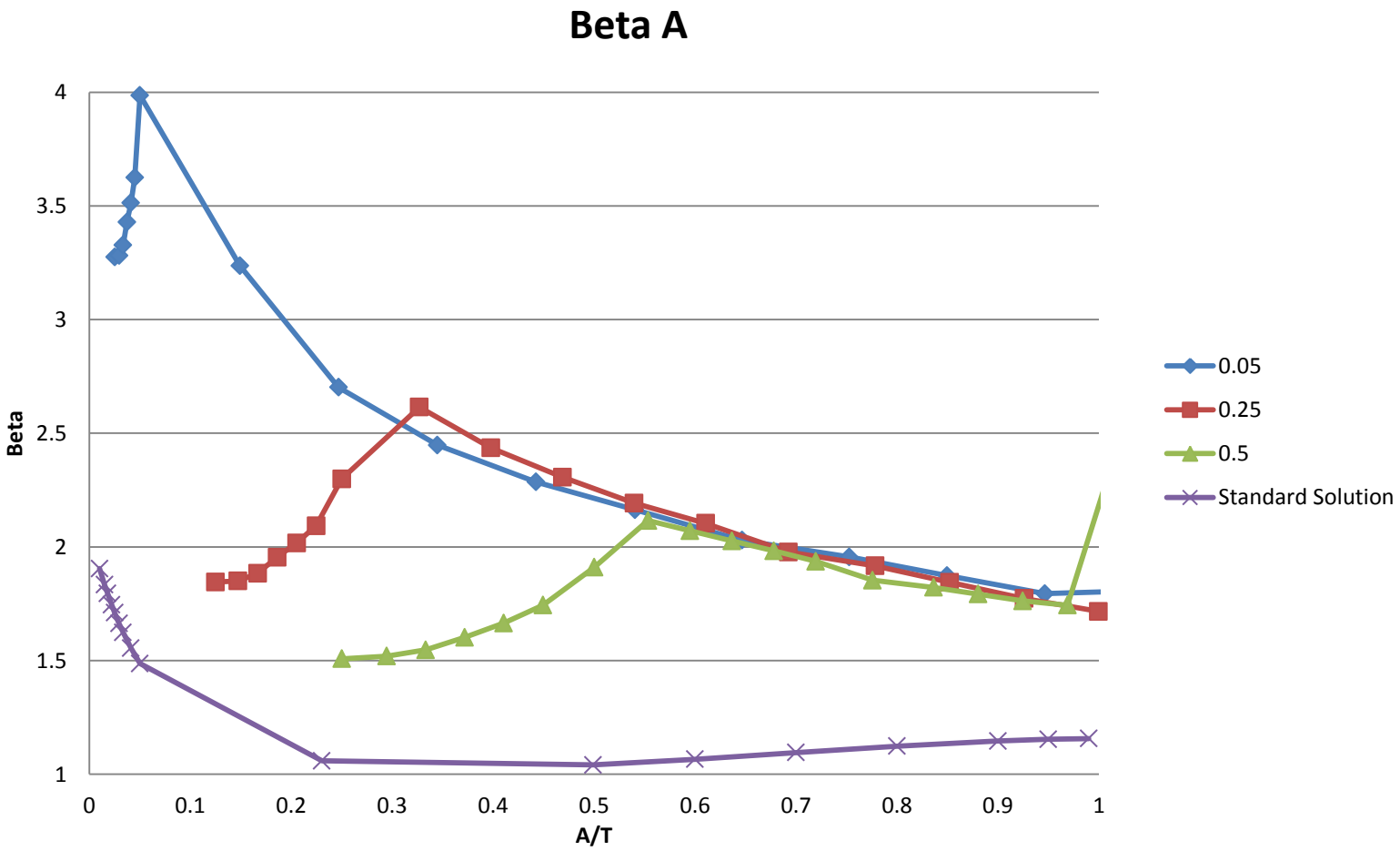
Countersunk Data Review



Countersunk Data Review



Countersink Data at Crack Front

20 points along crack front

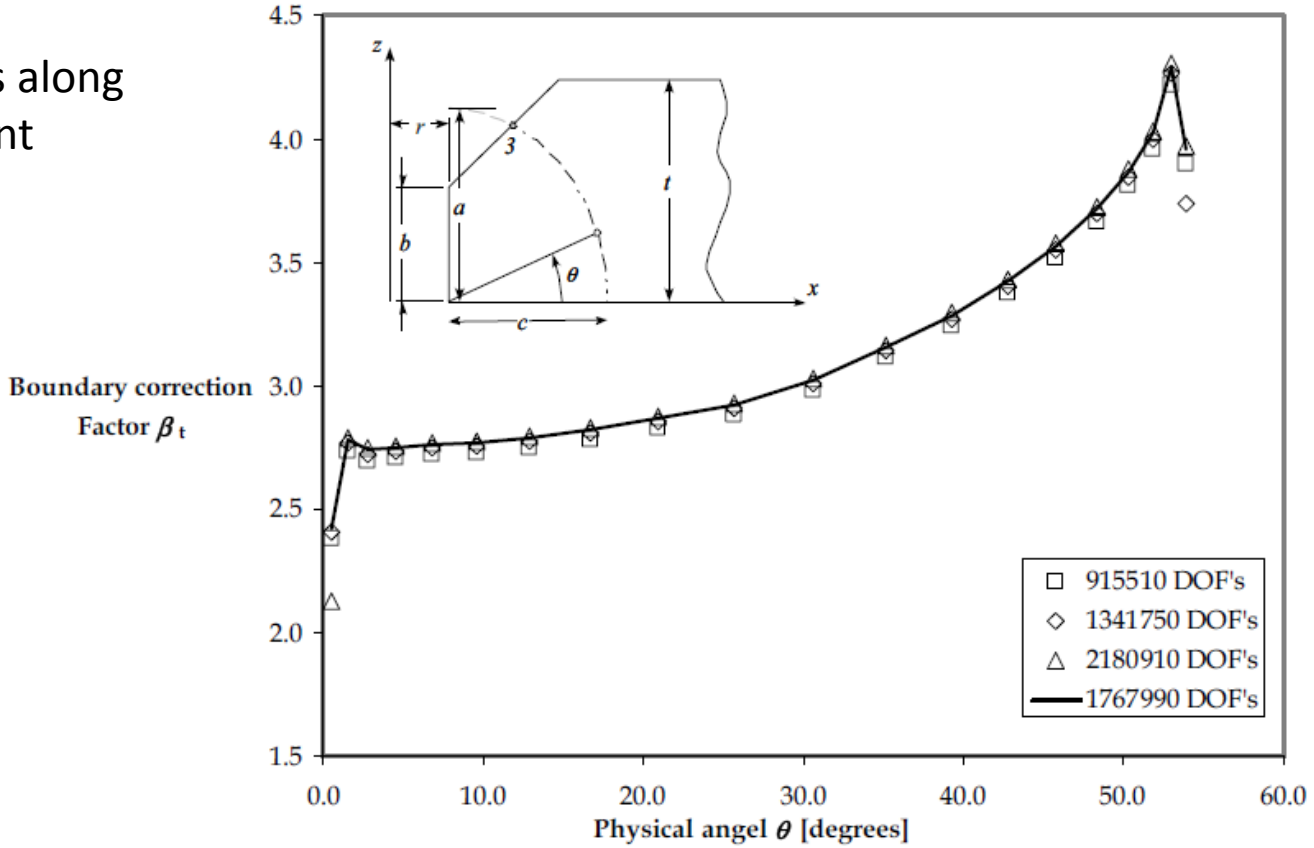
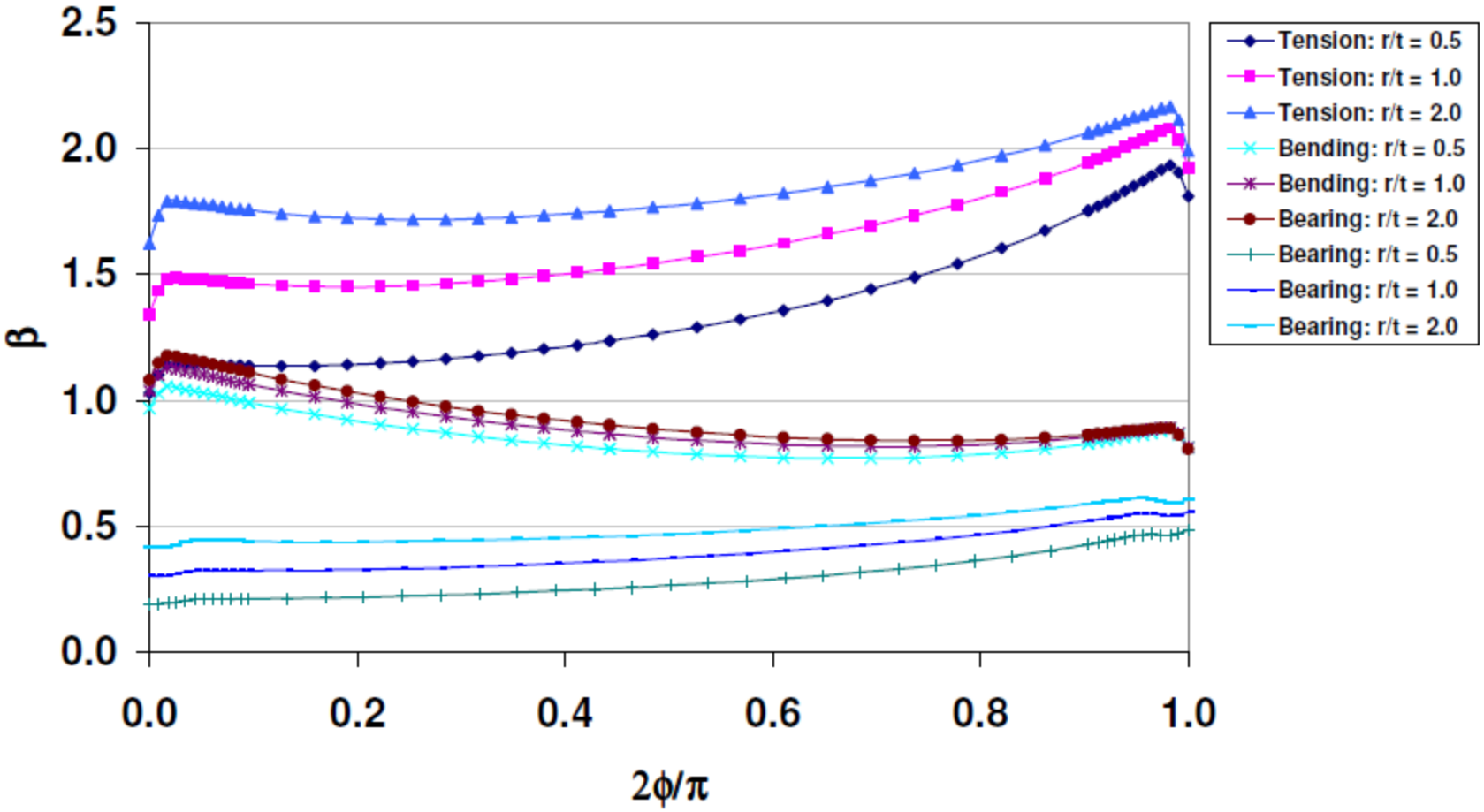


Figure 5-23 Convergence study for crack at countersunk hole subjected to tensile loading

Reinier de Rijck



APES 2002 report

Countersink Data at Crack Front Test Results (Tension)

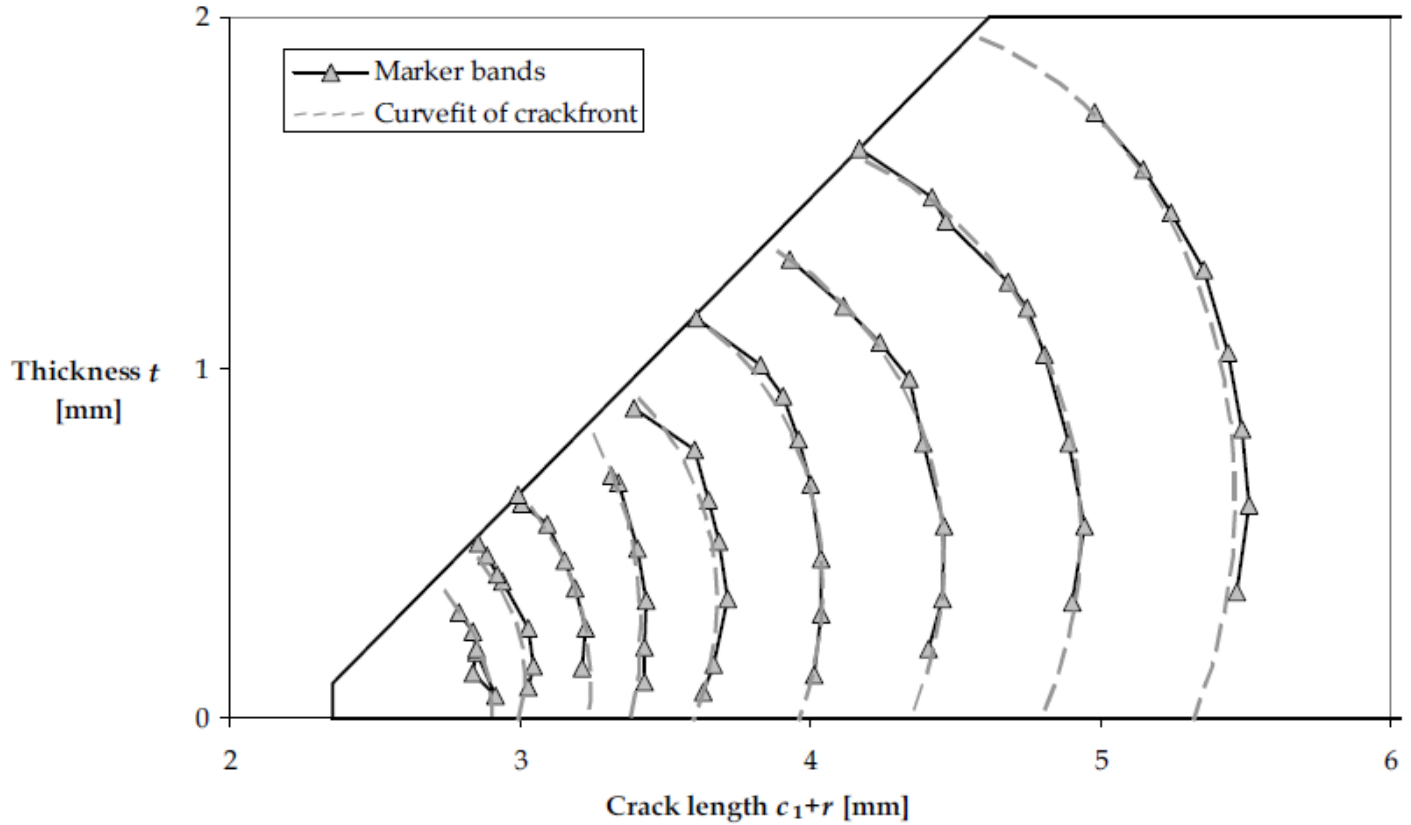


Figure 5-13 Crack fronts reconstructed for pure tension from marker bands

Reinier de Rijck

Countersink Data at Crack Front Test Results (Combine Loading)

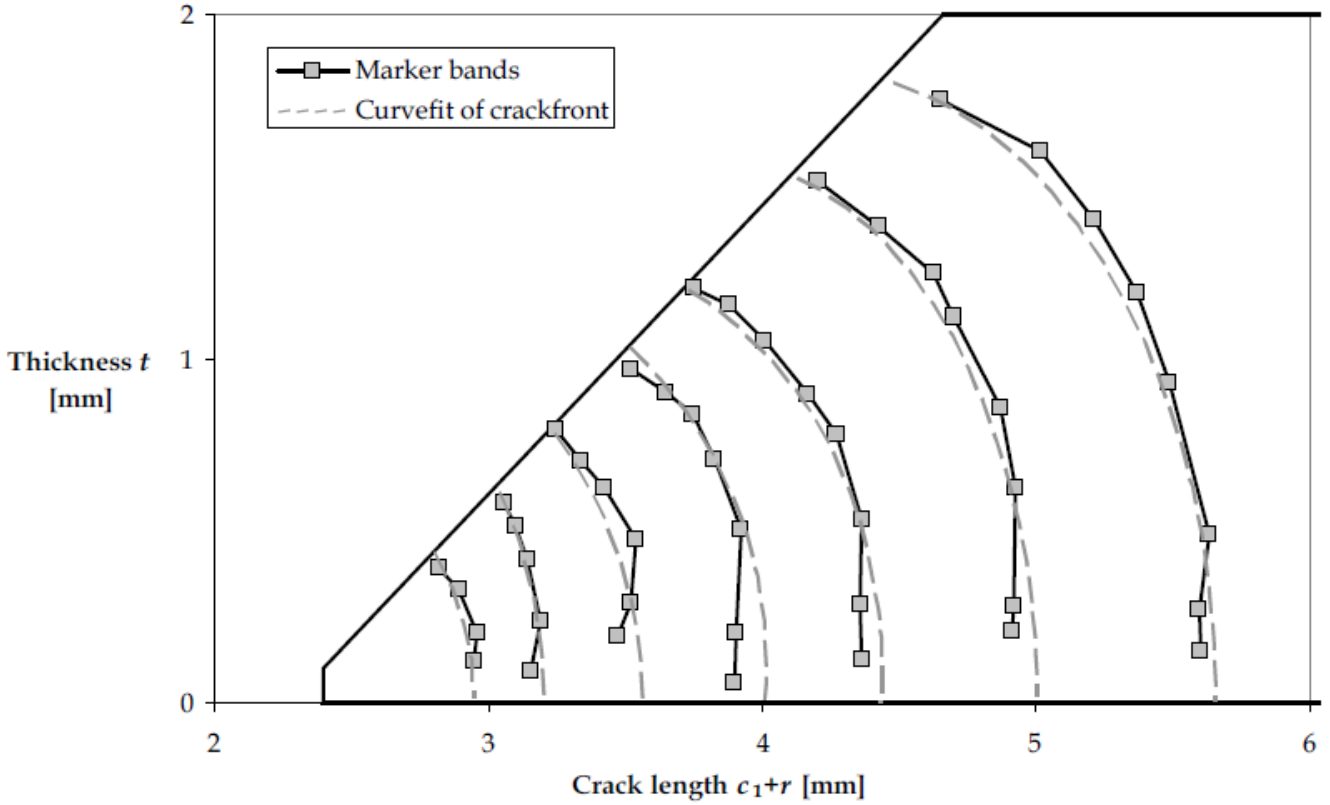


Figure 5-15 Crack front reconstruction for combined loading from the marker bands

Reinier de Rijck

AFGROW Countersink Crack Propagation

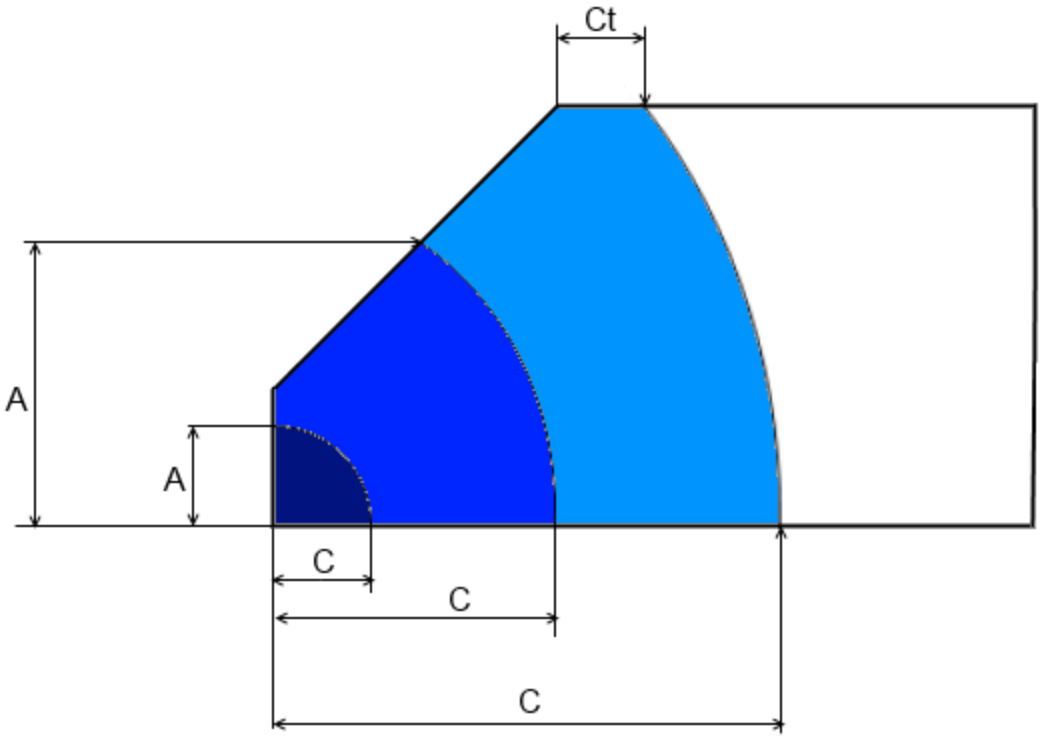
How AFROW propagates 2D crack

- 2 Points
- Elliptical Shape
- In Standard models historically 0 and 90 degrees were not selected
- We selected 2nd and 19th point of the data on the crack front (approximately 3 and 97 degrees)

						Load	$2\phi_c/\pi$	$2\phi_a/\pi$	β_c	β_a
						Tension	0.04	0.98	1.5355	2.4668
						Bending	0.03	0.98	1.1131	1.6111
						Bearing	0.05	0.97	0.3042	0.5276
						Tension	0.04	0.98	1.6527	2.3743
						Bending	0.03	0.97	1.0890	1.4745
						Bearing	0.05	0.97	0.3872	0.5837
						Tension	0.03	0.97	1.6744	2.2754
						Bending	0.03	0.97	1.0449	1.3644
						Bearing	0.05	0.97	0.4144	0.5823
						Tension	0.02	0.99	0.7363	1.8199
						Bending	0.02	0.99	0.7269	1.0752
						Bearing	0.05	0.97	0.1122	0.4260
5	0.50	0.50	b/2t	1.00	0.25	Tension	0.02	0.99	0.9805	1.8961
5	0.50	0.50	b/2t	1.00	0.25	Bending	0.02	0.97	0.7713	1.0515
5	0.50	0.50	b/2t	1.00	0.25	Bearing	0.05	0.97	0.2083	0.5074
6	0.50	0.50	b/2t	2.00	0.25	Tension	0.02	0.97	1.1843	1.9285

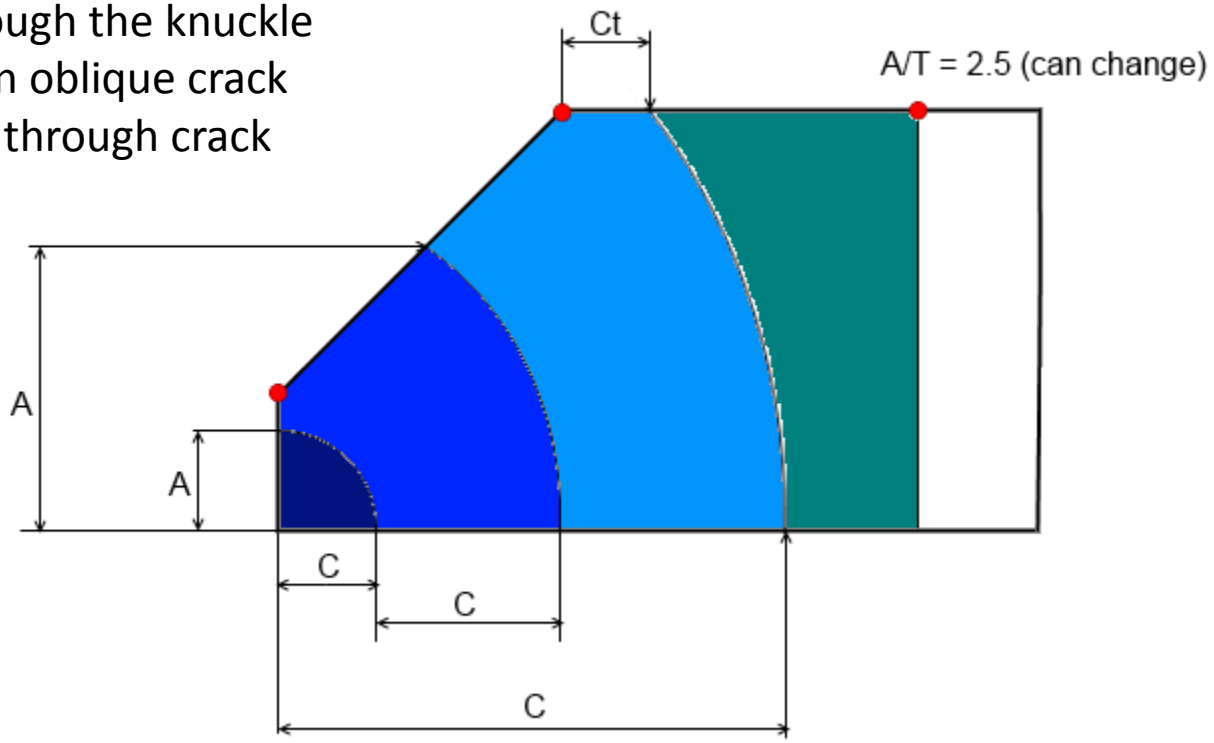
APES 2002 report

Countersunk Solution Crack Length Definition



Countersunk Corner Crack At Hole Transition Points

- Through the knuckle
- To an oblique crack
- To a through crack



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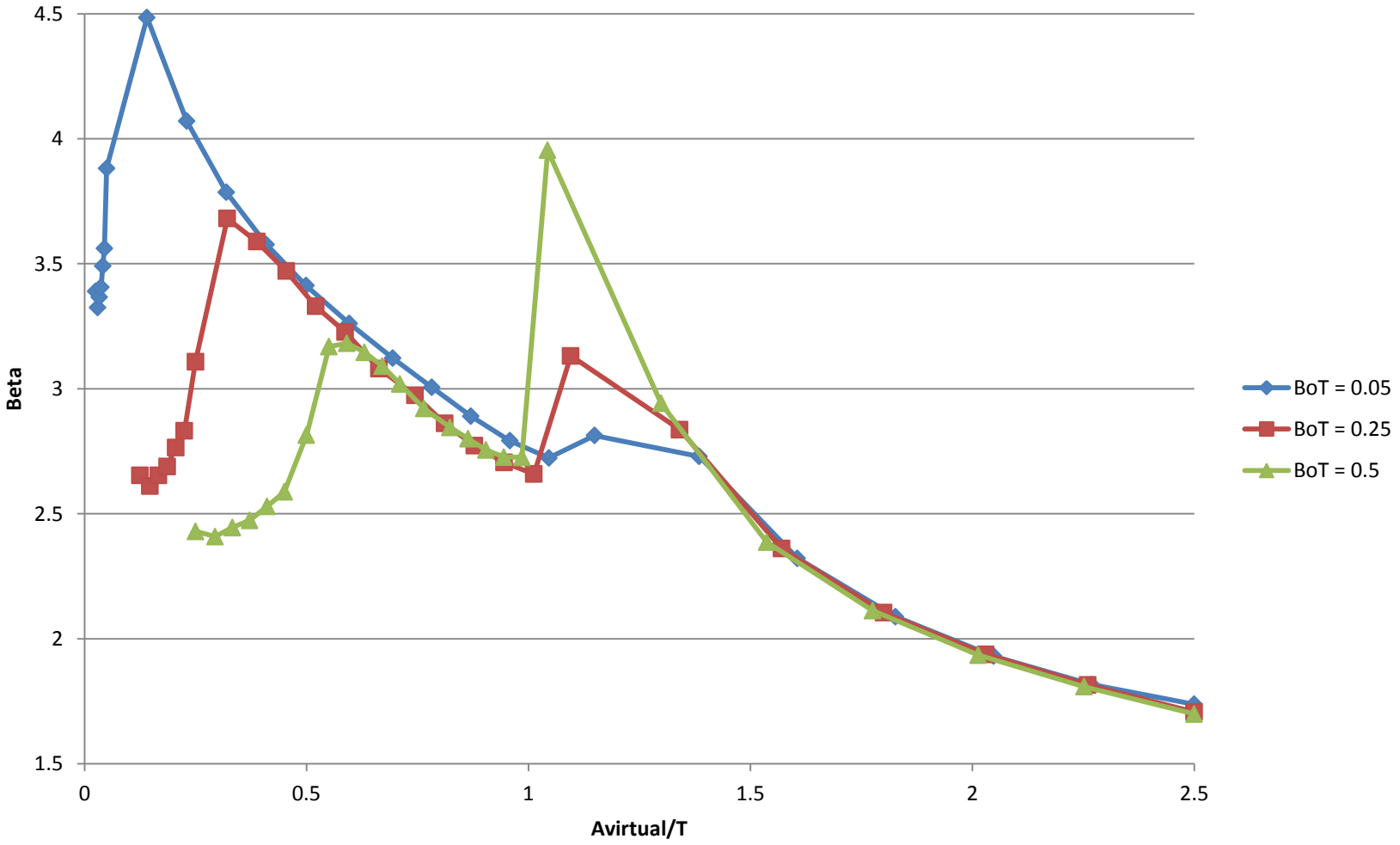
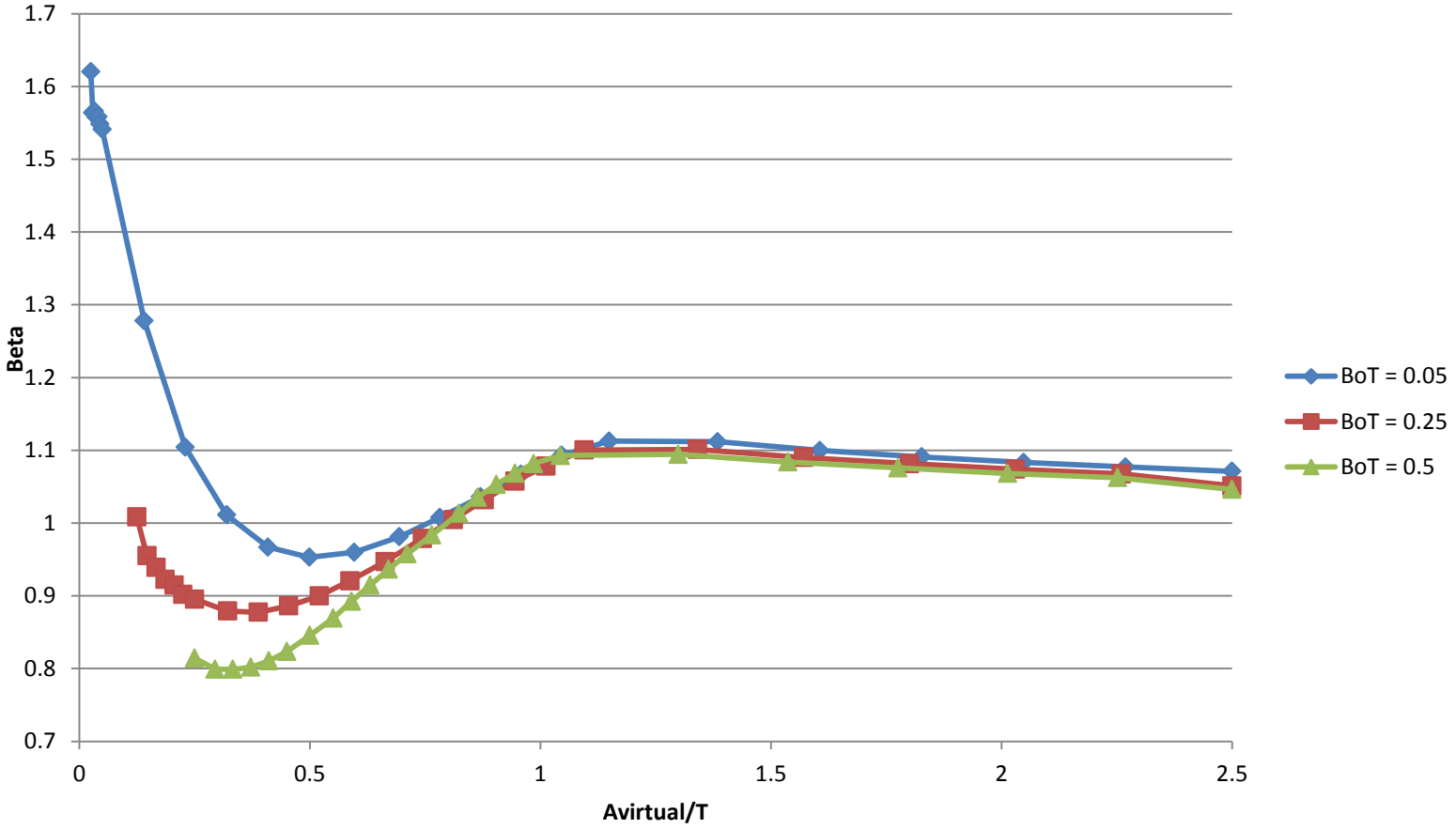
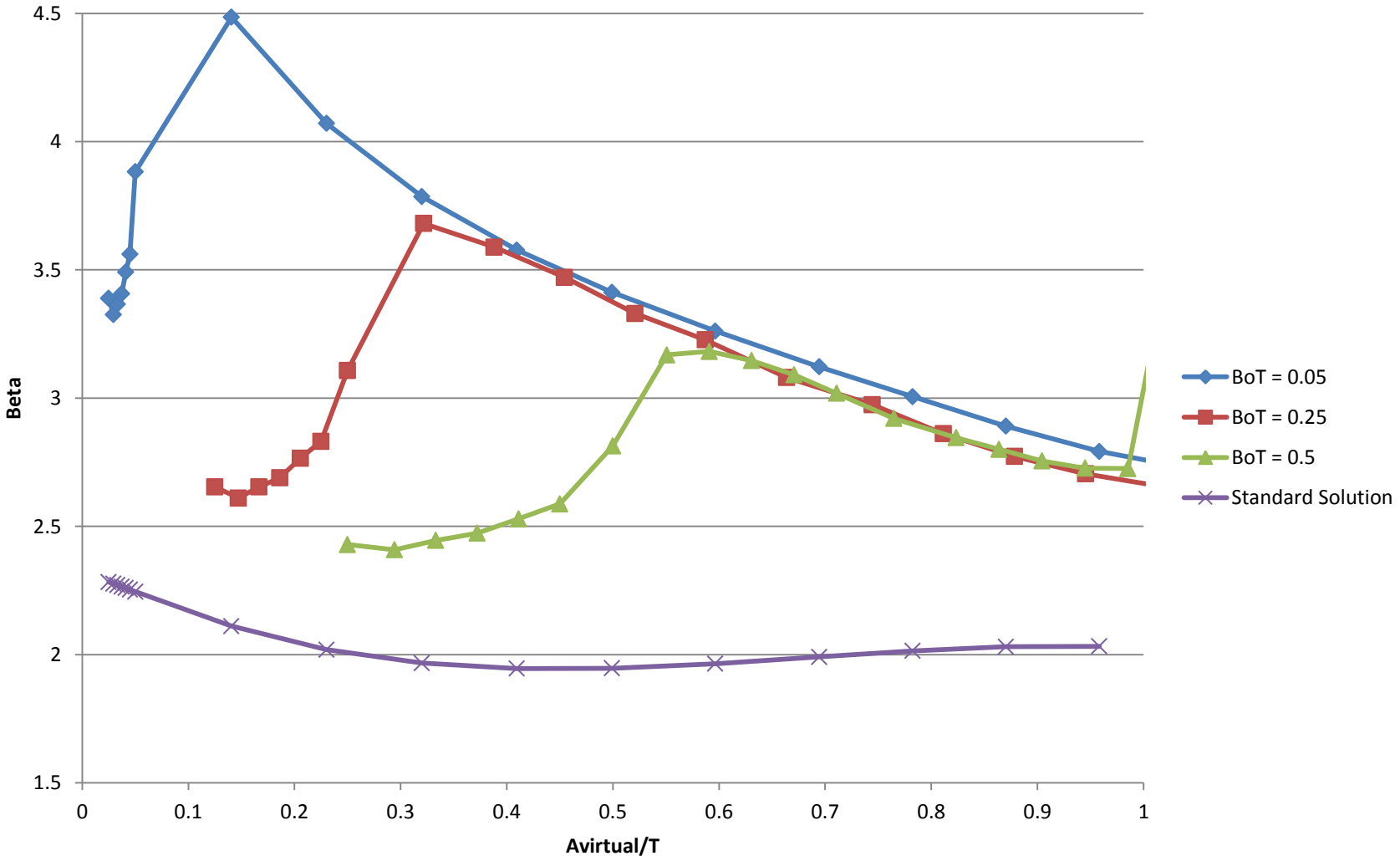
Countersunk Solution Beta A



Countersunk Solution Beta C



Countersunk Solution Beta A Comparison



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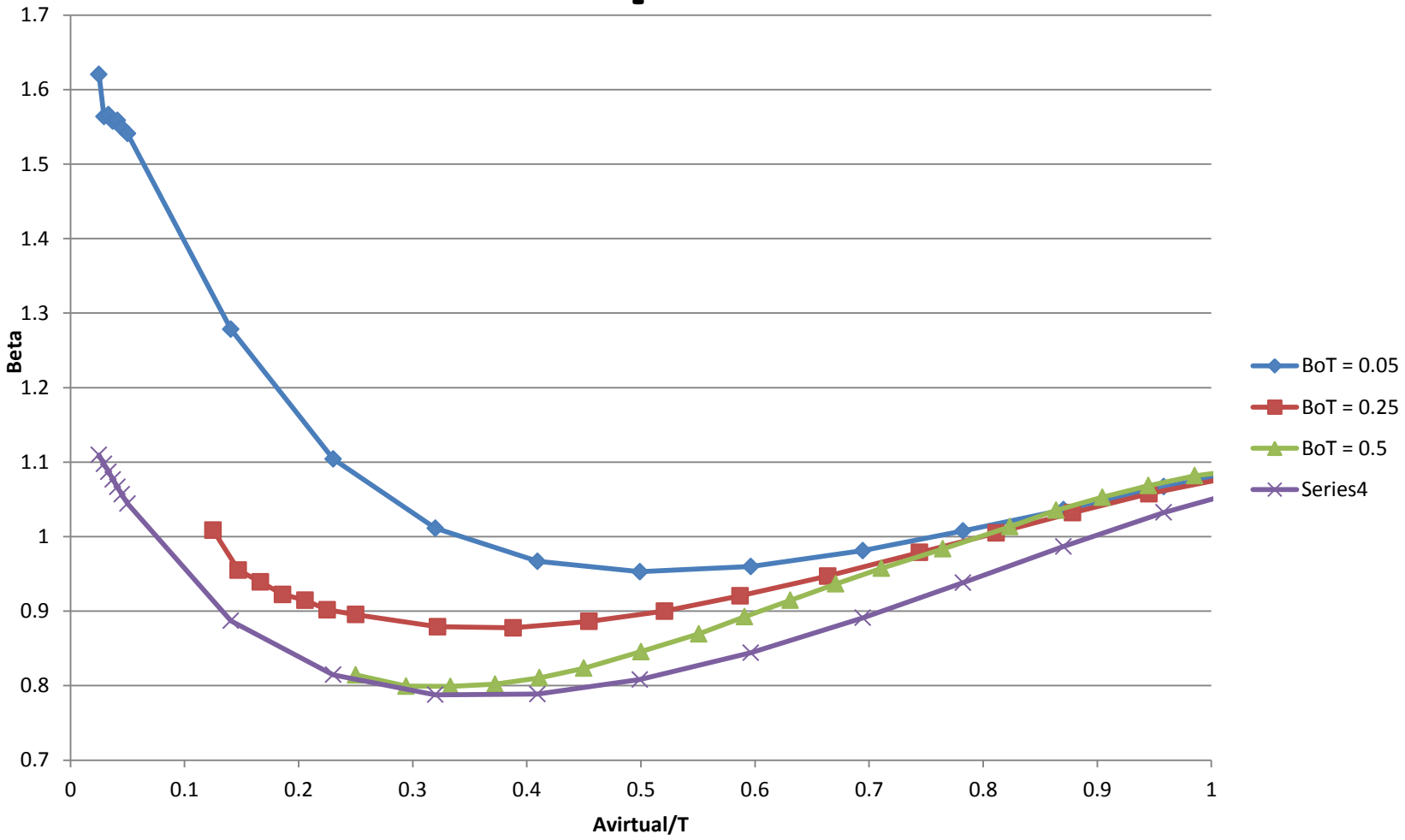
Countersunk Solution Beta C Comparison



Countersunk Solution Manual Data Extension

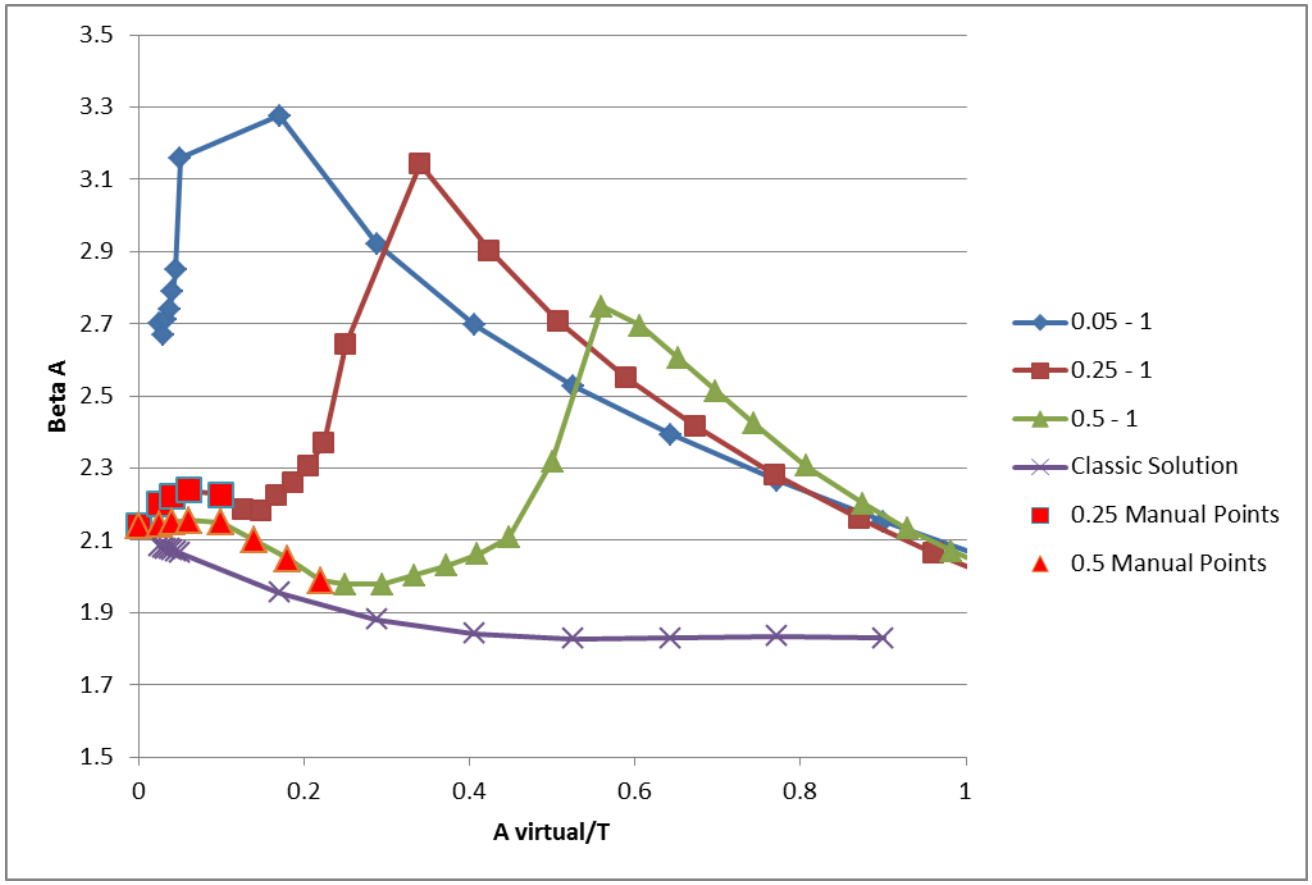
Data Analysis

1. B-0.05 starts from 0.025 Avirtual/T, B-0.25 from 0.125 and B-0.5 starts from 0.25
2. When A/C =5, B=0.5 data are missing completely
3. Random holes in the data matrix
4. Different A/C ratios extend to different final Avirtual/T, from 2.4 to 70.00
5. We did not fix the existing data points, just extend left and/or right and add additional curves

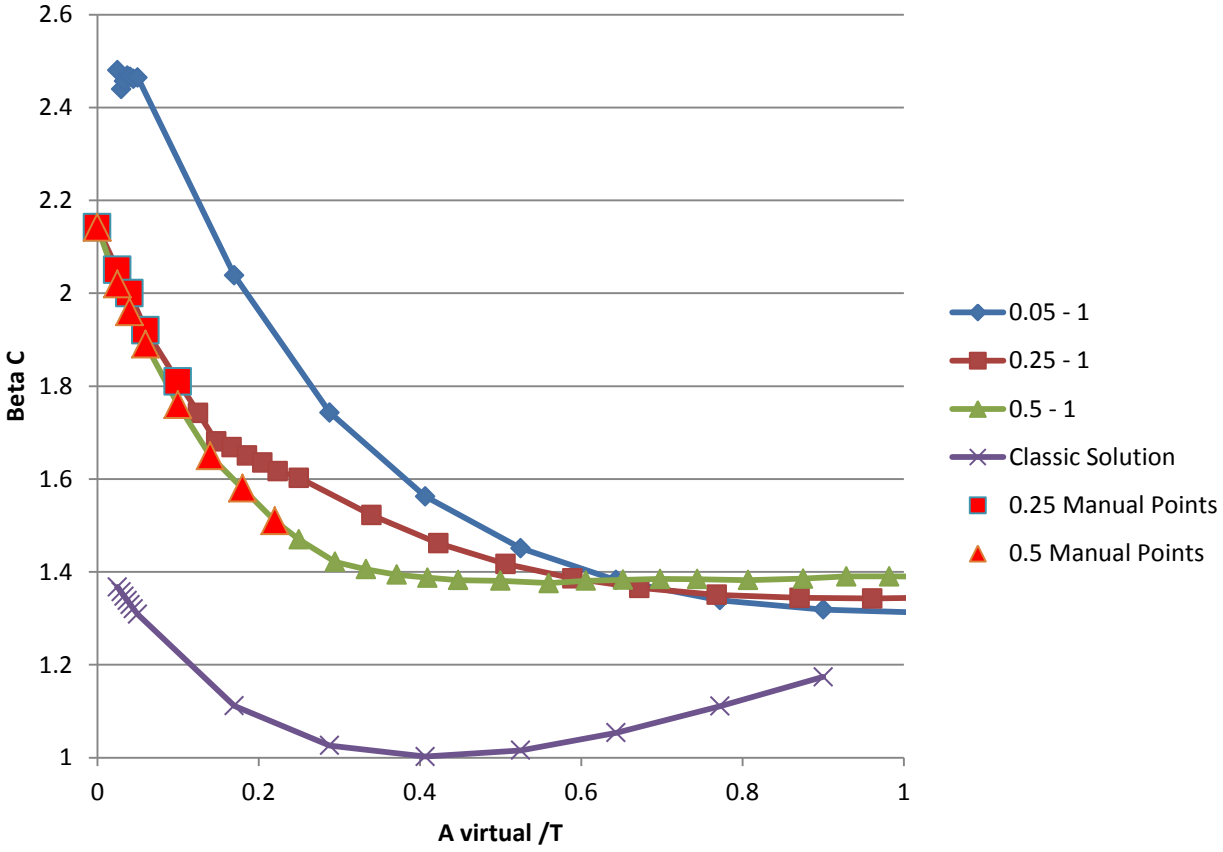
Manual Work for Tension

1. Added about 2000 data points to extend the curves
2. Added about 150 new curves
3. Plotted 200 about graphs
4. Did it 3 times

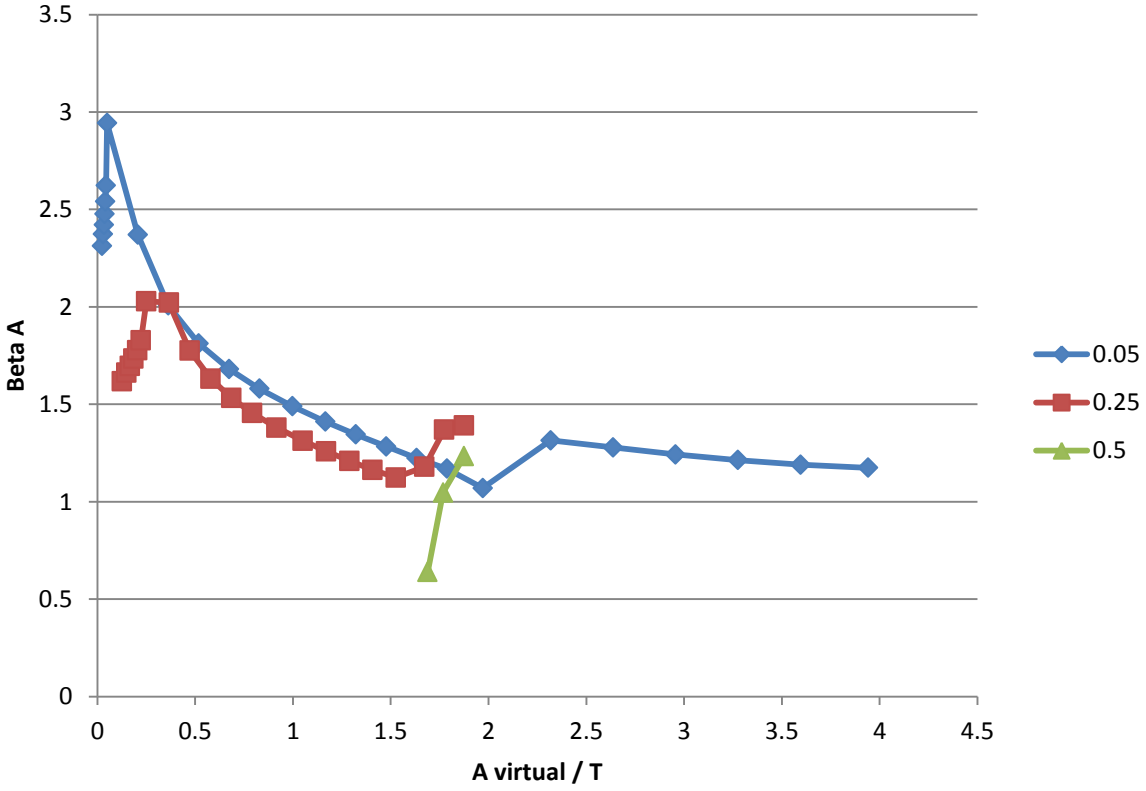
Countersunk Solution Beta A Data Extension



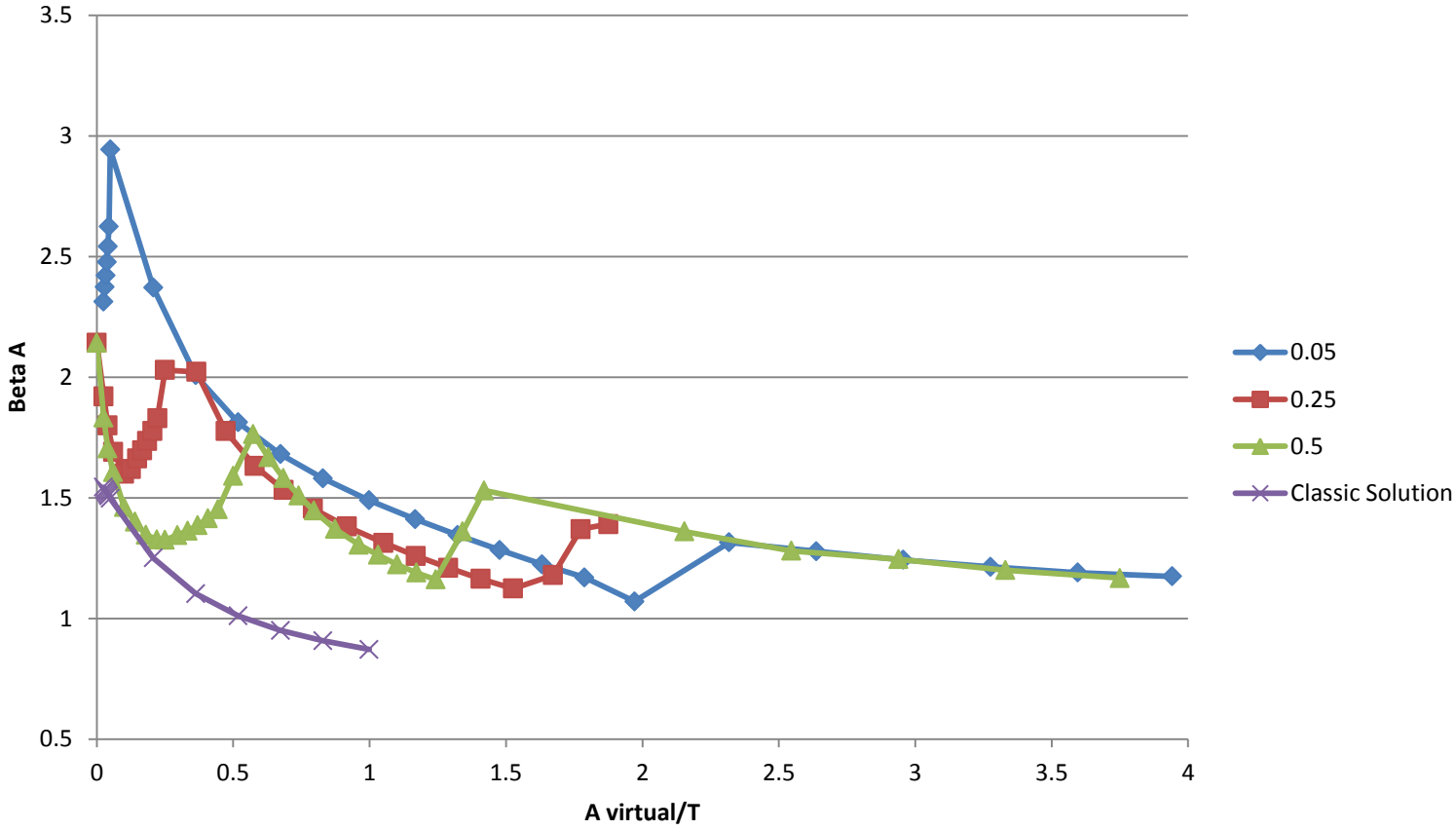
Countersunk Solution Beta C Data Extension



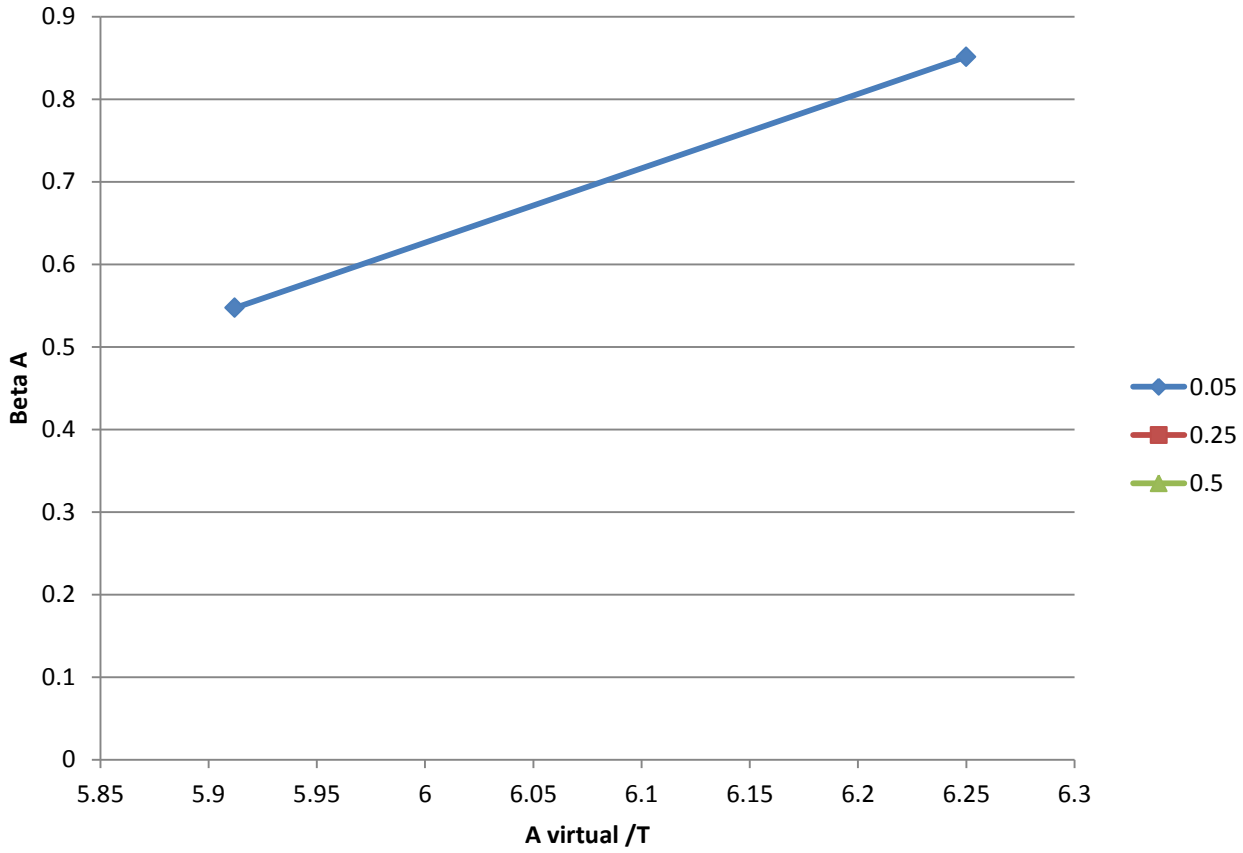
Countersunk Solution Random Data Fixes



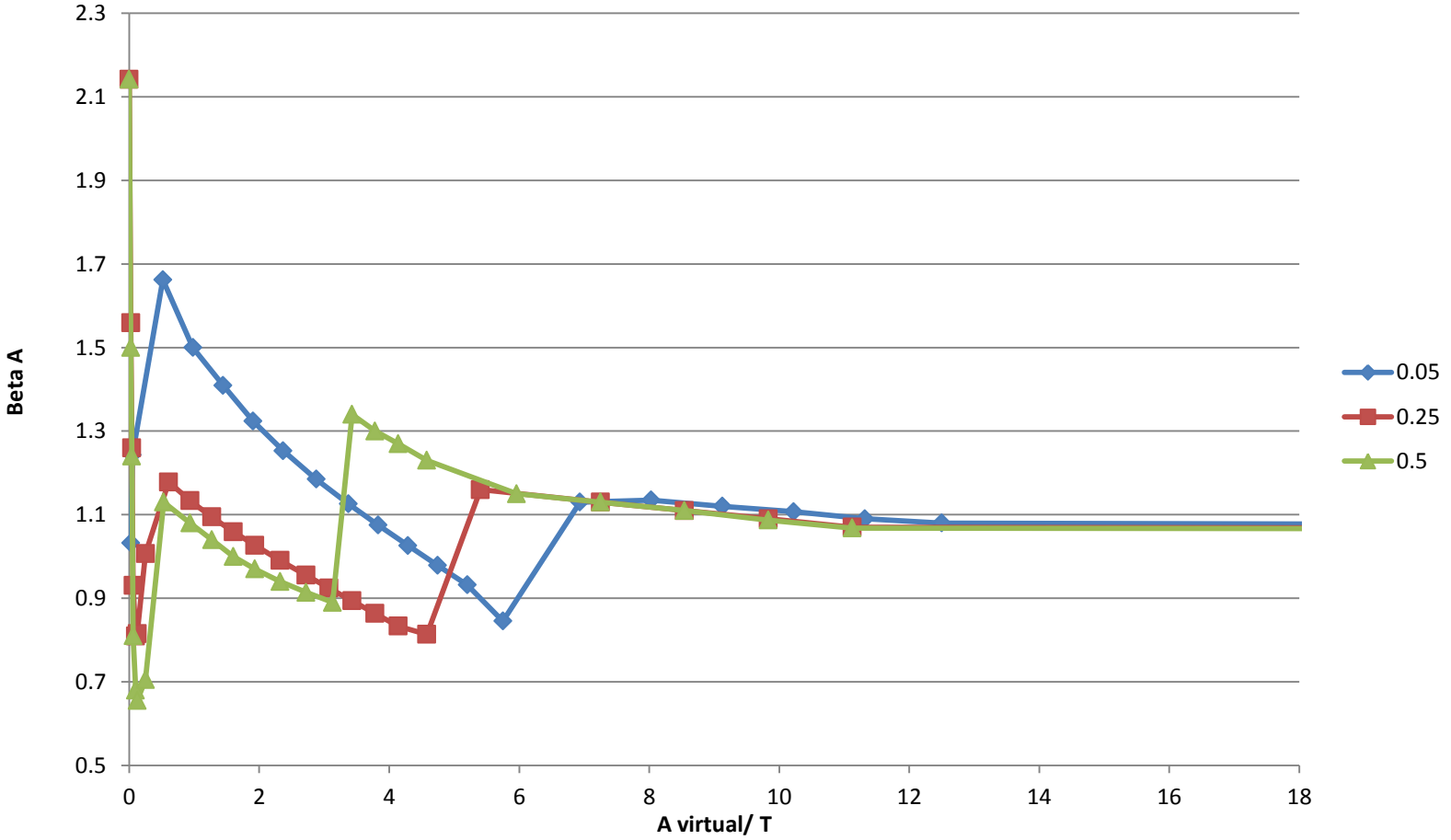
Countersunk Solution Random Data Fixes



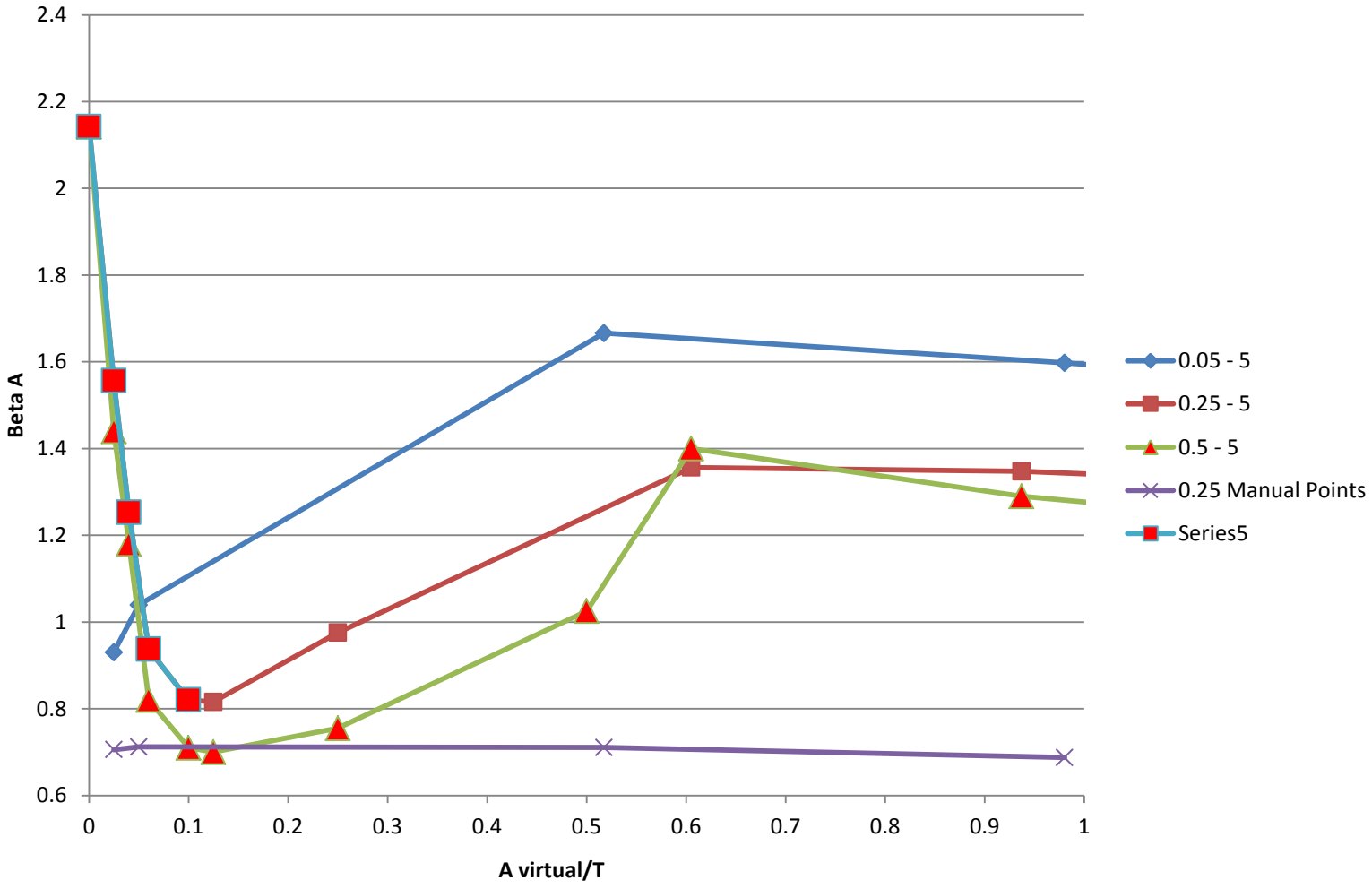
Countersunk Solution Random Data Fixes



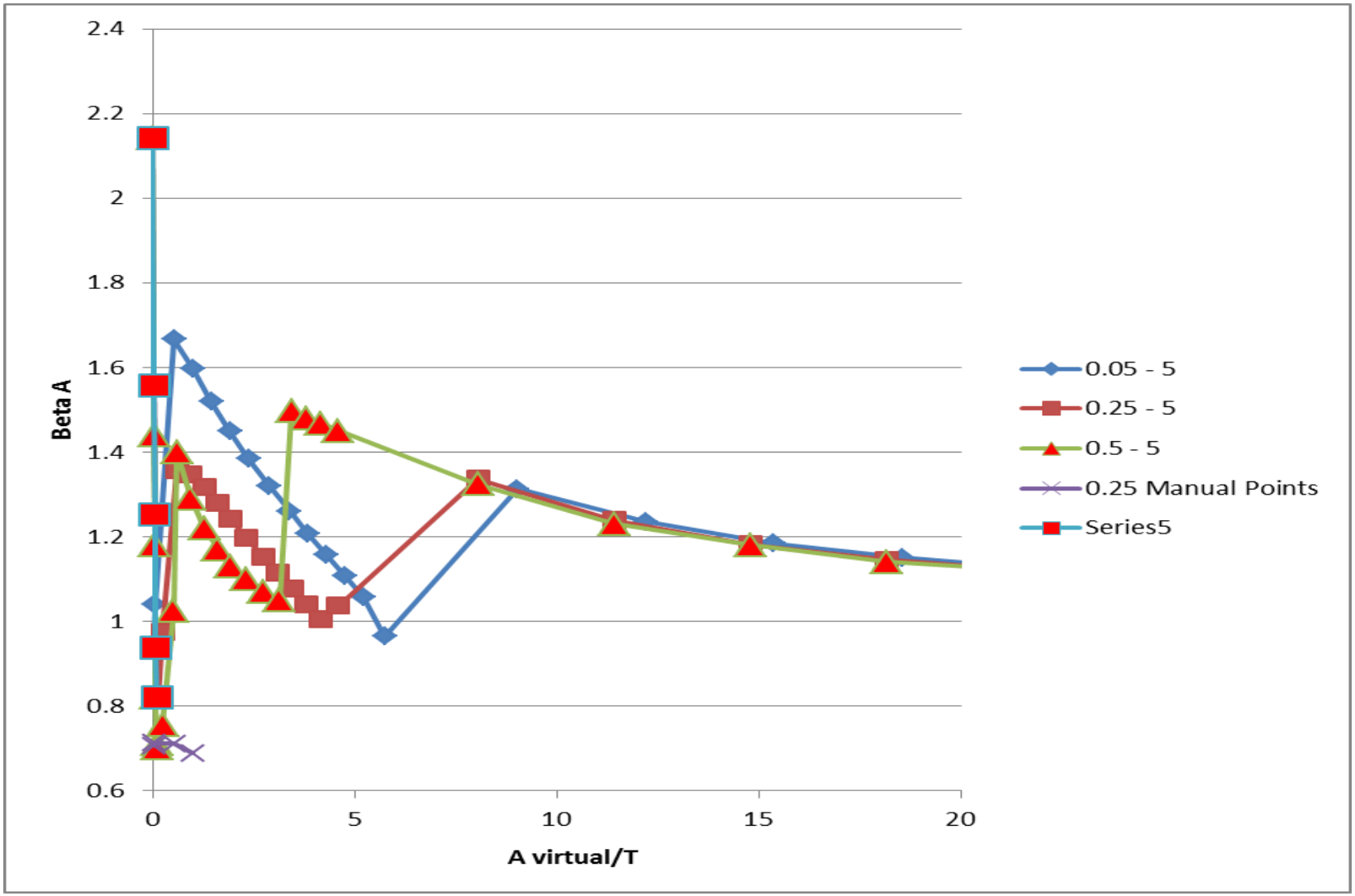
Countersunk Solution Random Data Fixes



Countersunk Solution A/C = 5 Issues



Countersunk Solution A/C = 5 Issues



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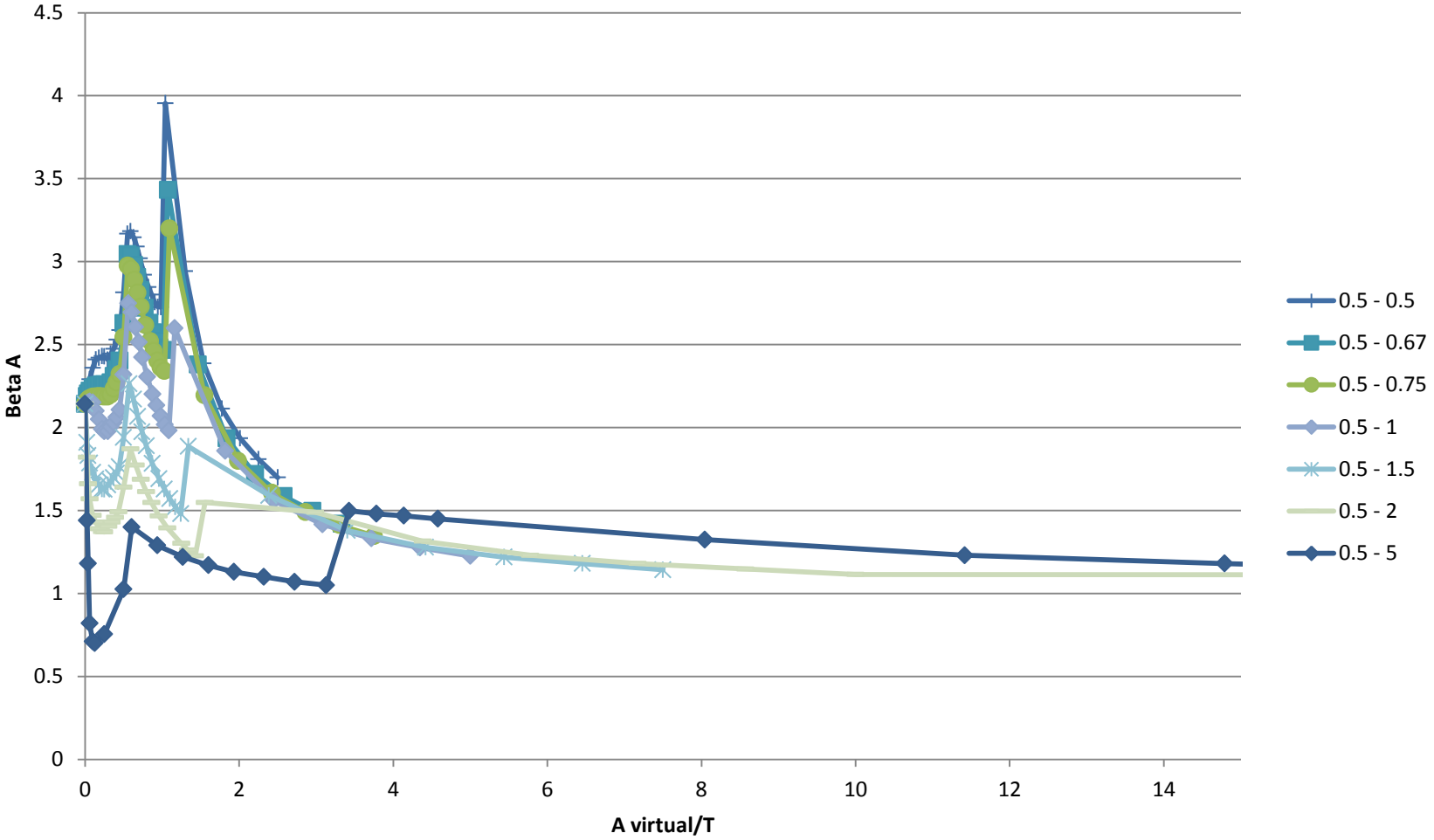
Countersunk Solution Issues Fixed?



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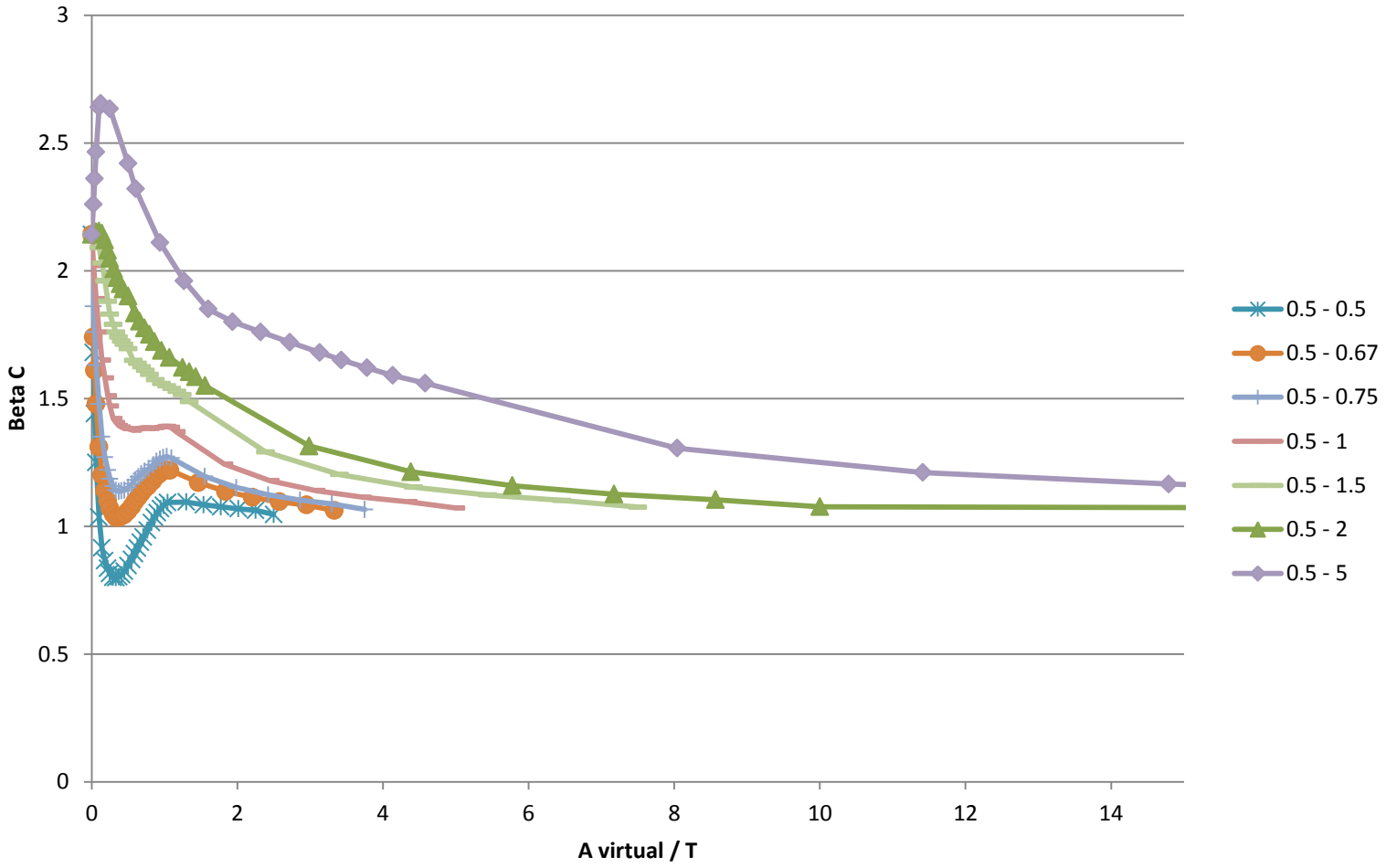
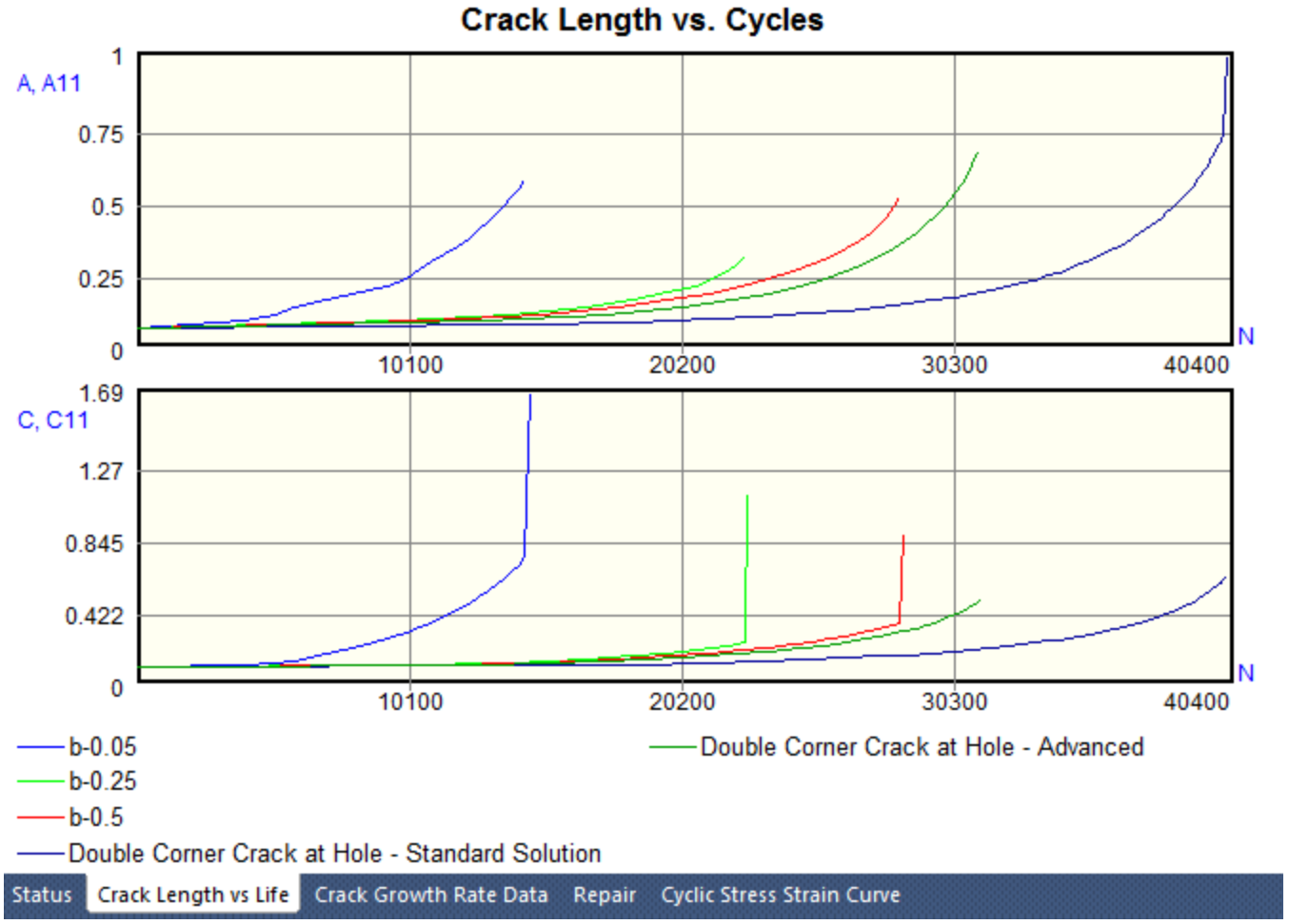
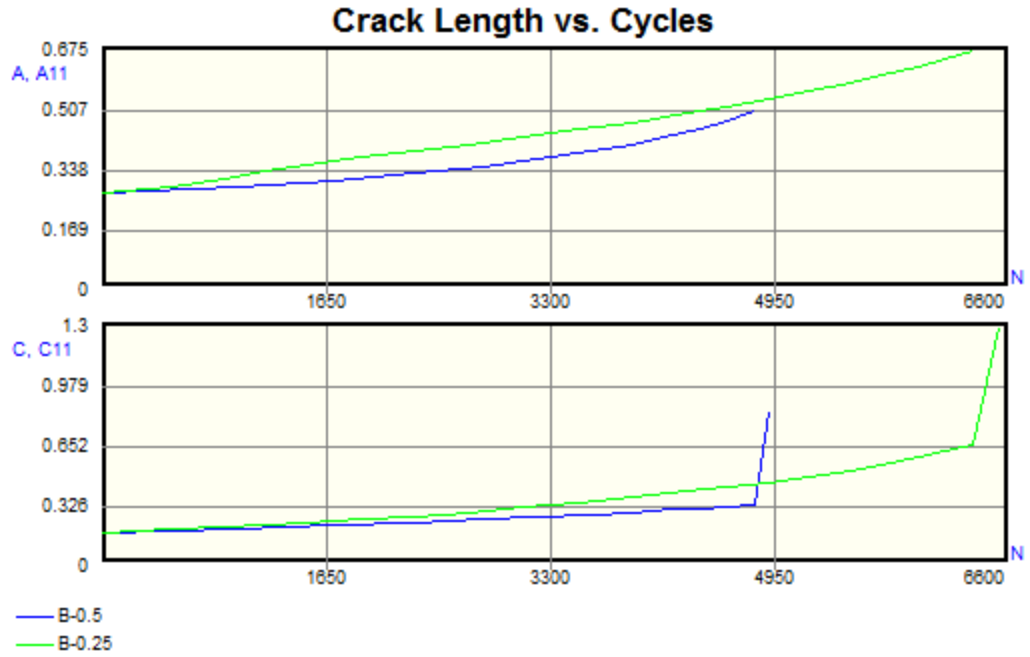
Countersunk Solution Issues Fixed?

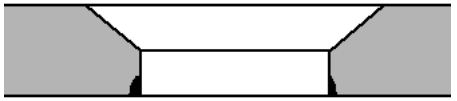


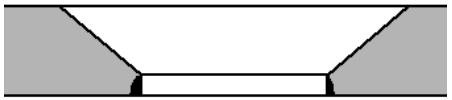
Countersunk Solution Fixed?, Continued



Countersunk Solution Fixed?, Continued

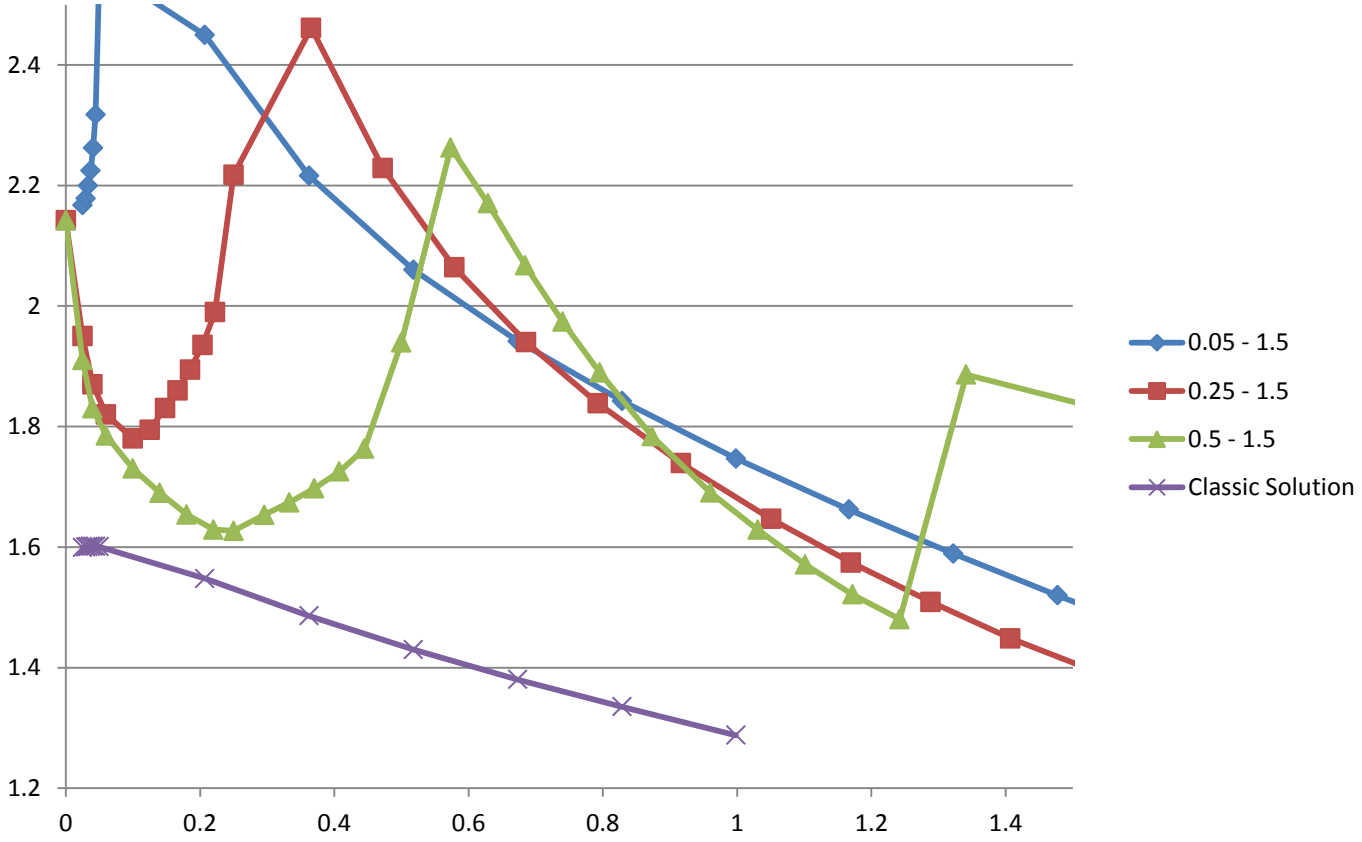




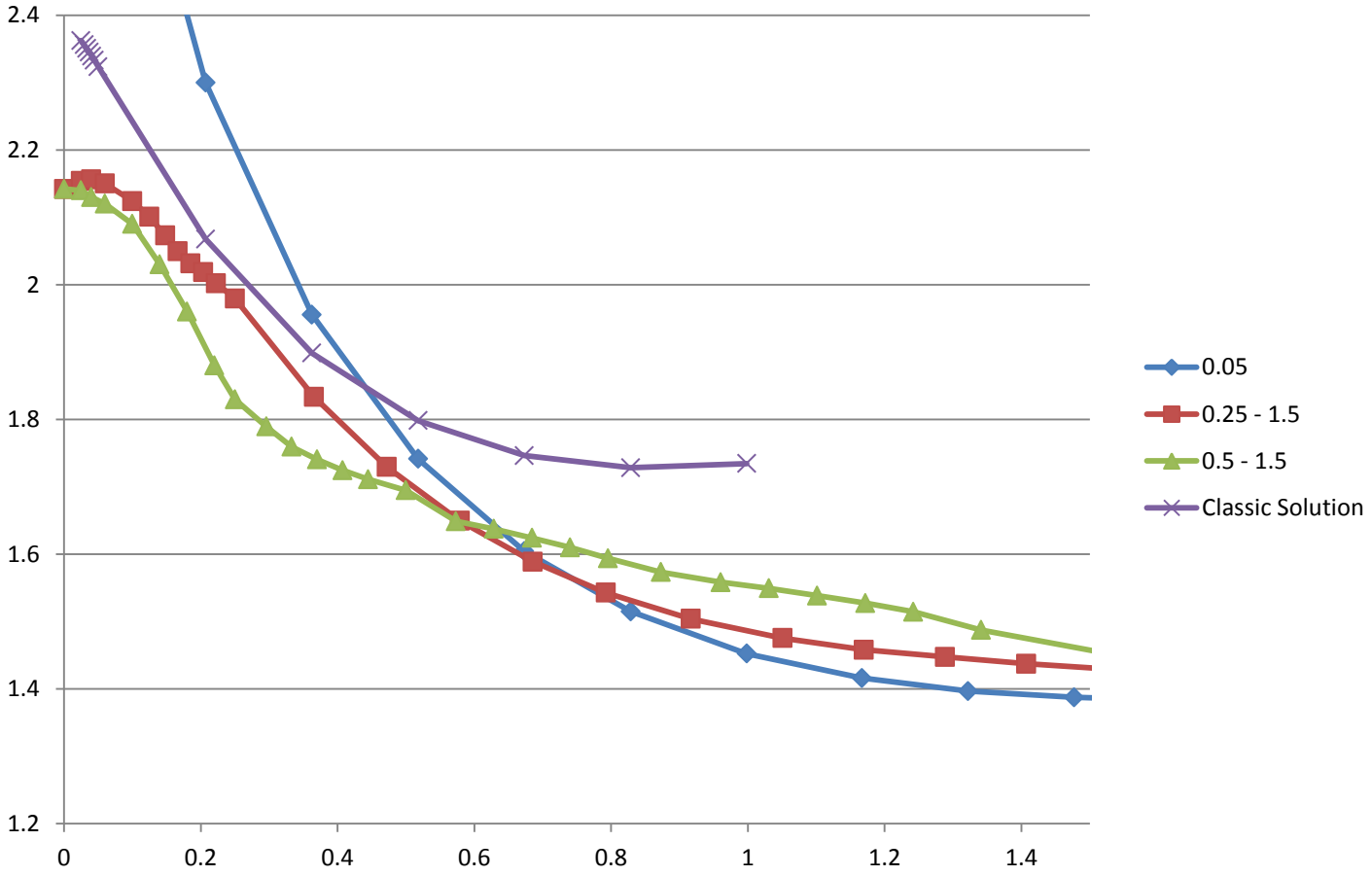


Status | Crack Length vs Life | Crack Growth Rate Data | Repair | Cyclic Stress Strain Curve

Countersunk Solution Fixed?, Continued



Countersunk Solution Fixed?, Continued



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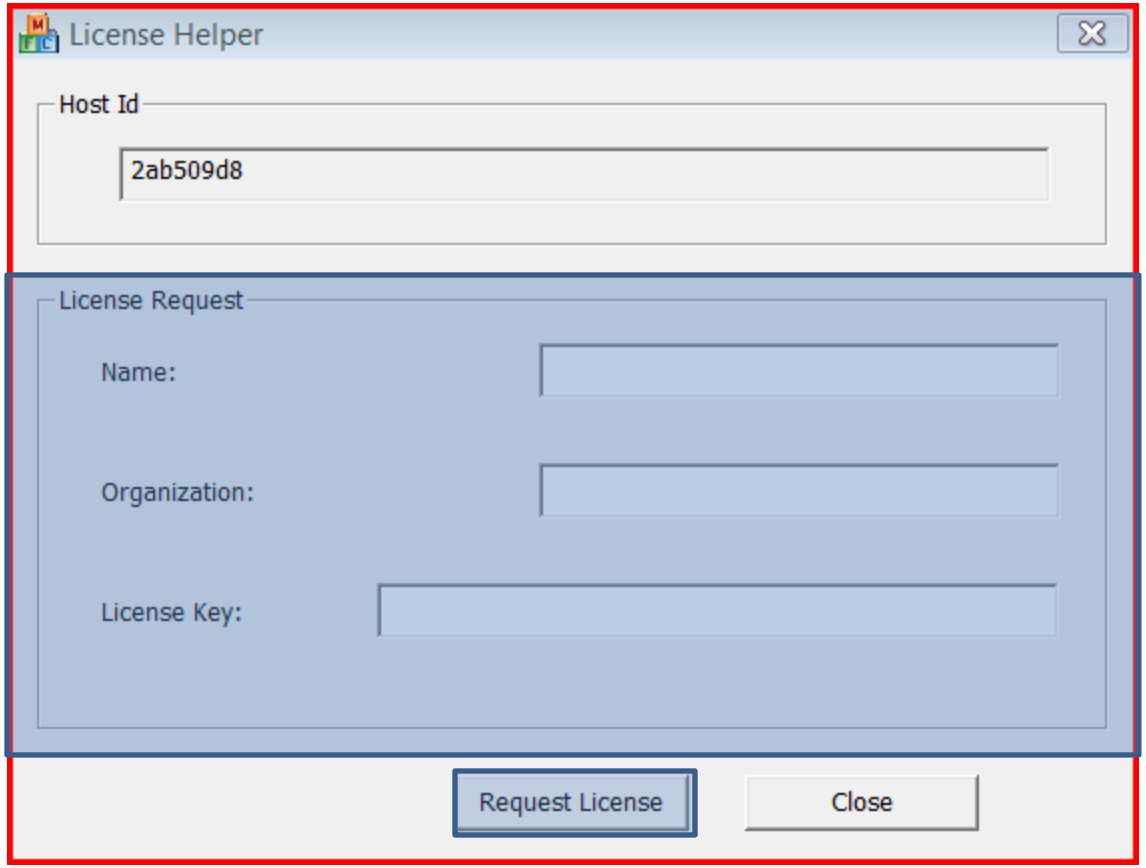
Countersunk Solution Beta C Comparison with APES

r	b	a	c	BetaA rea	BetaC real	BetaA Afg	BetaC Afg	% Beta A	% Beta C
0.125	0.0125	0.00625	0.0125	3.488582	1.5355	3.432	1.4875	-1.64866	3.226891
0.25	0.0125	0.00625	0.0125	3.357767	1.6527	3.3952	1.623	1.025194	1.829945
0.5	0.0125	0.00625	0.0125	3.217902	1.6744	3.3167	1.657	2.978818	1.050091
0.25	0.0625	0.03125	0.0625	2.68149	0.9805	2.6586	1.0103	-0.86099	-2.94962
0.5	0.0625	0.03125	0.0625	2.727311	1.1843	2.8541	1.2391	4.442351	-4.22565

W = 40
T= 0.25

License Helper



1. Helps node locked license users find the host id of the computer
2. Can be used to generate the license file automatically based on the supplied by LexTech license key

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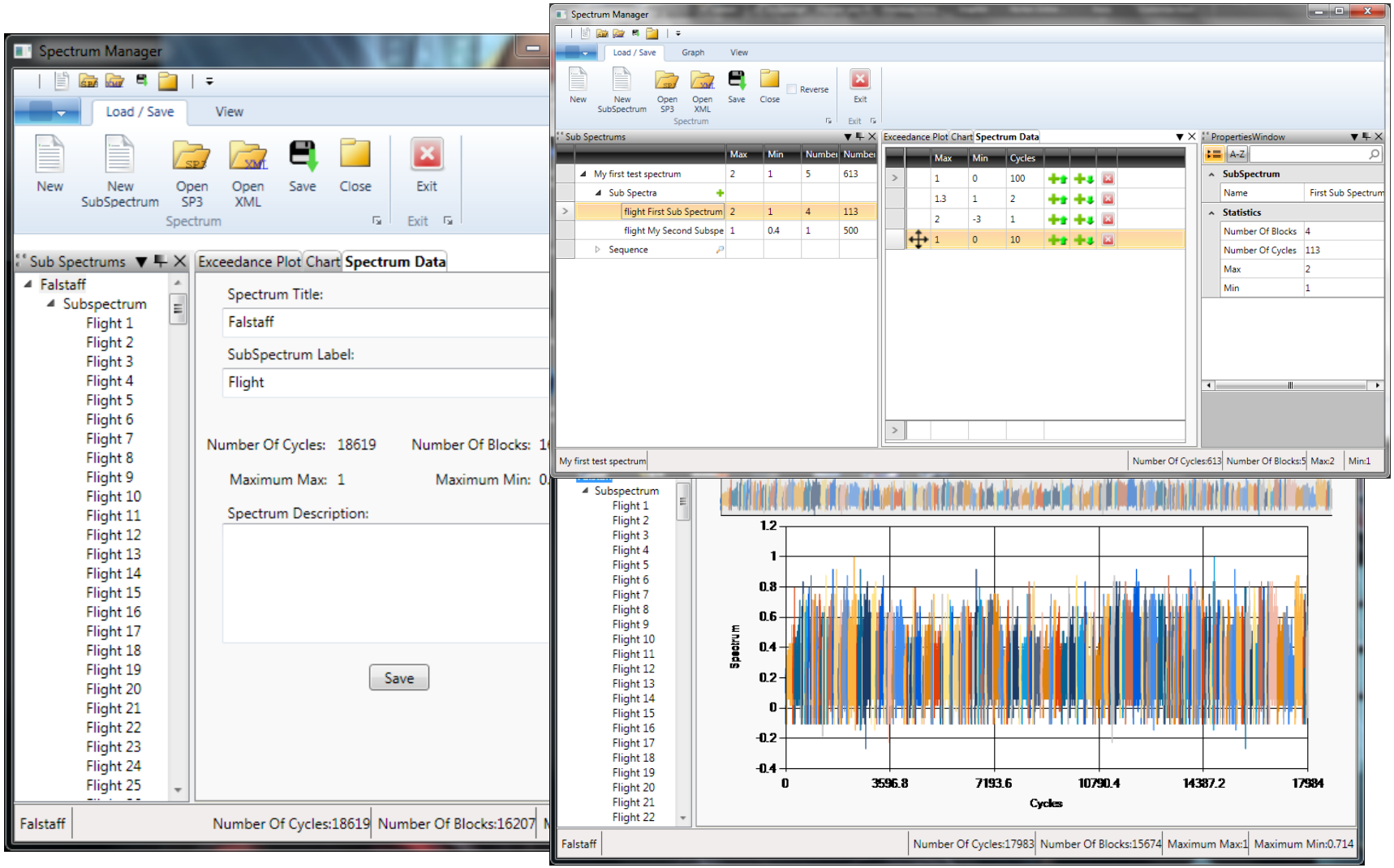
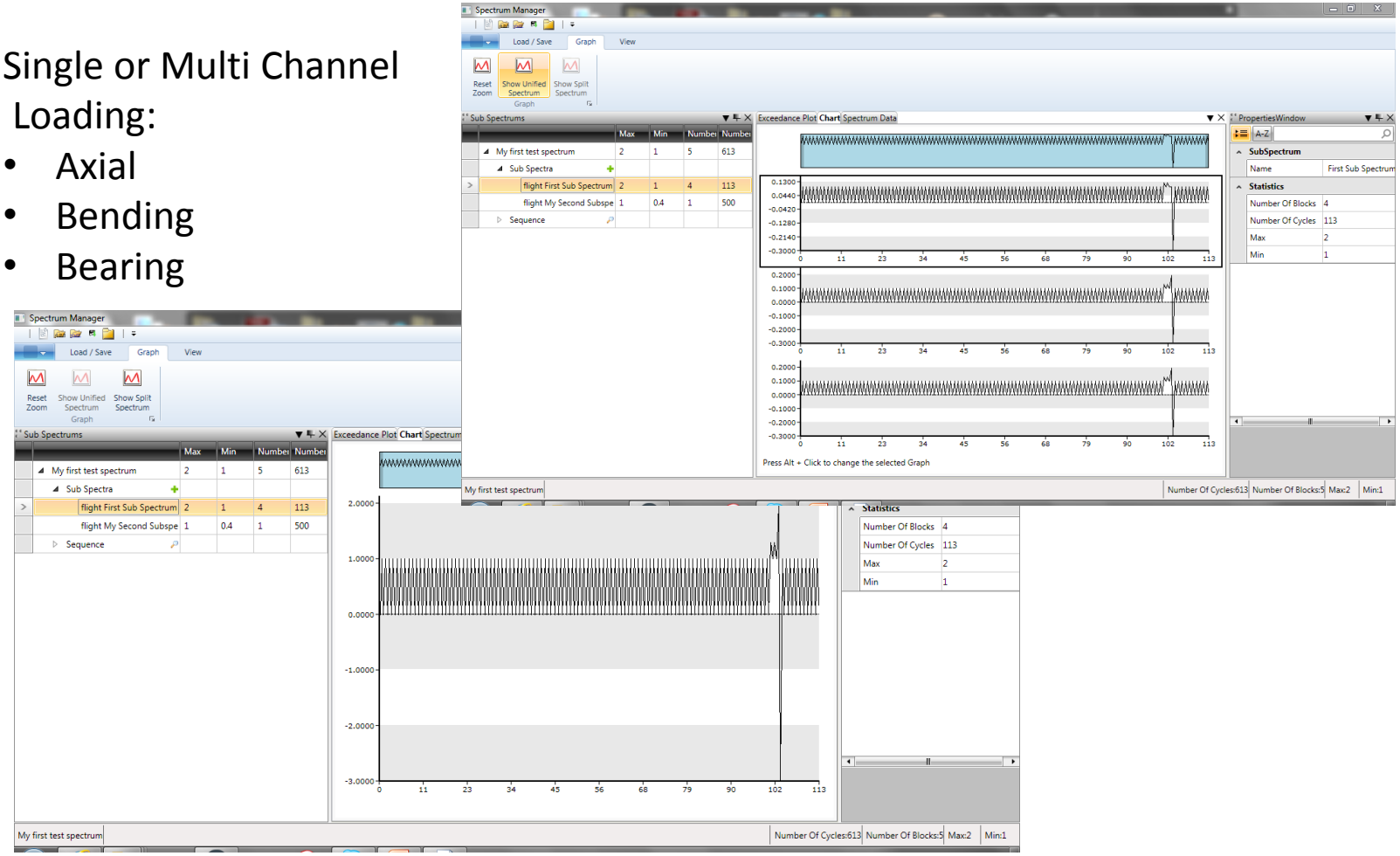
Spectrum Tool



Spectrum Tool

Single or Multi Channel Loading:

- Axial
- Bending
- Bearing



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Spectrum Tool

- Visual spectrum design
- Spectrum Statistics at a glance
- Clipping
- Truncation
- Spectrum reversal (flip Min with Max, requested by Northrop)
- Spectrum level reordering
- Copy-Paste from Excel
- Sub spectra re-ordering

Crack Closure Factor

- Why do we have it?
- Applied only on a crack at the open edge surface
- Added to standard, user defined, advanced and plug-in k solutions

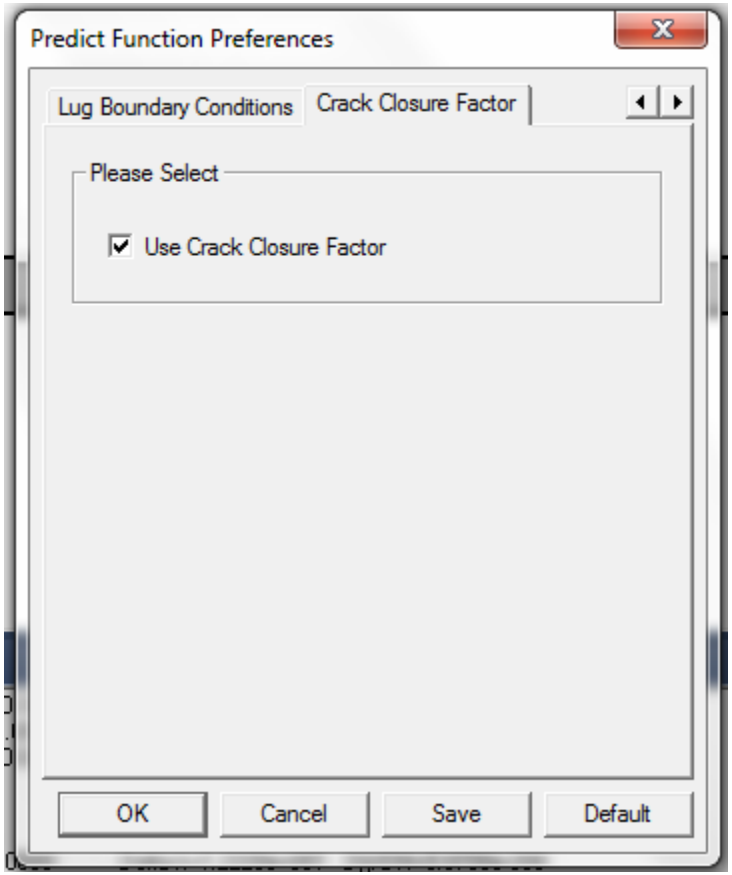
$$K = \beta_r * \sigma\sqrt{Length * \pi} * \beta$$

if $R = 0$
then

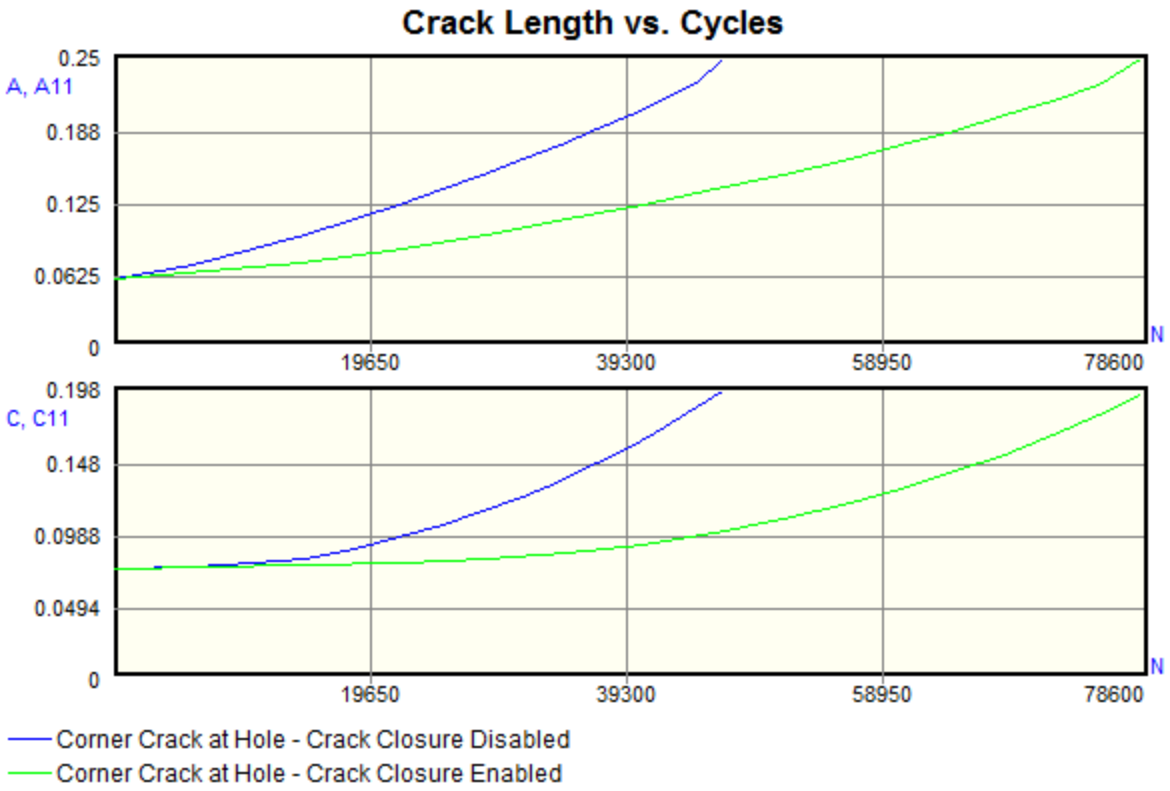
$$\beta_r = 0.9$$

else

$$\beta_r = 0.9 + 0.2 * R^2 - 0.1 R^4$$



Crack Closure Factor



Plug-in API changes

- New function that sets the Afgrow Application Object in the Plugin
- New function that Afgrow uses to request effective thickness from plugin. This function used only when NASGO material model is selected, because NASGRO material model is thickness dependent.
- New notification event (***AfgrowEventRefreshModel***) that is called when Afgrow refreshes the plot window
- New notification event (***AfgrowEventBeforePredict***) that is called before Afgrow starts prediction and locks access to the COM interface

Plug-in API changes

- New notification event (***AfgrowEventDeltaLengthReady***) that is sent after Afgrow calculates crack increments
- Ability to set/get delta crack increments for each direction. Needs to be used together with ***AfgrowEventDeltaLengthReady*** notification event.
- Ability to set effective thickness for each direction. Needs to be set when ***AfgrowEventPredictStarted*** event is called.
- Ability to request the Min and Max stress
- Afgrow now calculates K failure
- Fixed bug that sometimes caused for output XML file to loose data

COM API changes

- Add the option to extract the Harter-T material parameters
- Add ability to extract and set the NASGRO equation material parameters
- Ability to extract and set the countersunk hole with the corner cracks parameters
- Ability to add extract and set Crack Closure factor
- Fixed bug in the CalculateBeta function (did not work with the advanced models)

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Beta 1 Test Results

- AFGROW would not run on Windows XP or Vista – **Fixed**
- Random crashes when advanced models are used **- Fixed**
- Inability to save or modify files in the restricted windows folders – **Can not be fixed, will either need programmatically elevate privileges of the user to Administrator (which is unpractical) or user files need to be located in the *Documents* folder. Installation is modified and changes of the user files default folder in AFGROW are in process.**
- Crash and unexpected behavior while using beta correction data – **Fixed**
- Crash and unexpected behavior while using residual stresses – **Fixed**
- Crash while loading wrong tabular lookup data – **In process (need to add an additional error checking)**
- AFGROW file icons are not registered with Windows during an installation **– Probably Fixed**

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Questions