

AFGROW Workshop 2014

AFGROW Release 5.2

Alex Litvinov, James Harter,
LexTech, Inc

Release 5.02 Overview

- Was release officially released on February 15, 2014
- Was 3.5 years in development and testing
- Was built using Microsoft Visual C++ 2010
- Includes a new GUI library
- Has multiple new features and bug fixes
- Some of the planned features were removed from the release due to the time constraints

Thank you

- Josh Hodges
- Michelle Creps
- Dalen Andrews - SwRI
- Luciano Smith - SwRI
- Bob Pilarczyk
- Scott Carlson - SwRI
- Scott Prost – Domasky – APES
- Scott Fawaz – SAFE
- Chad King

For helping us test and debug the new
release

Microsoft Visual C++ 2010

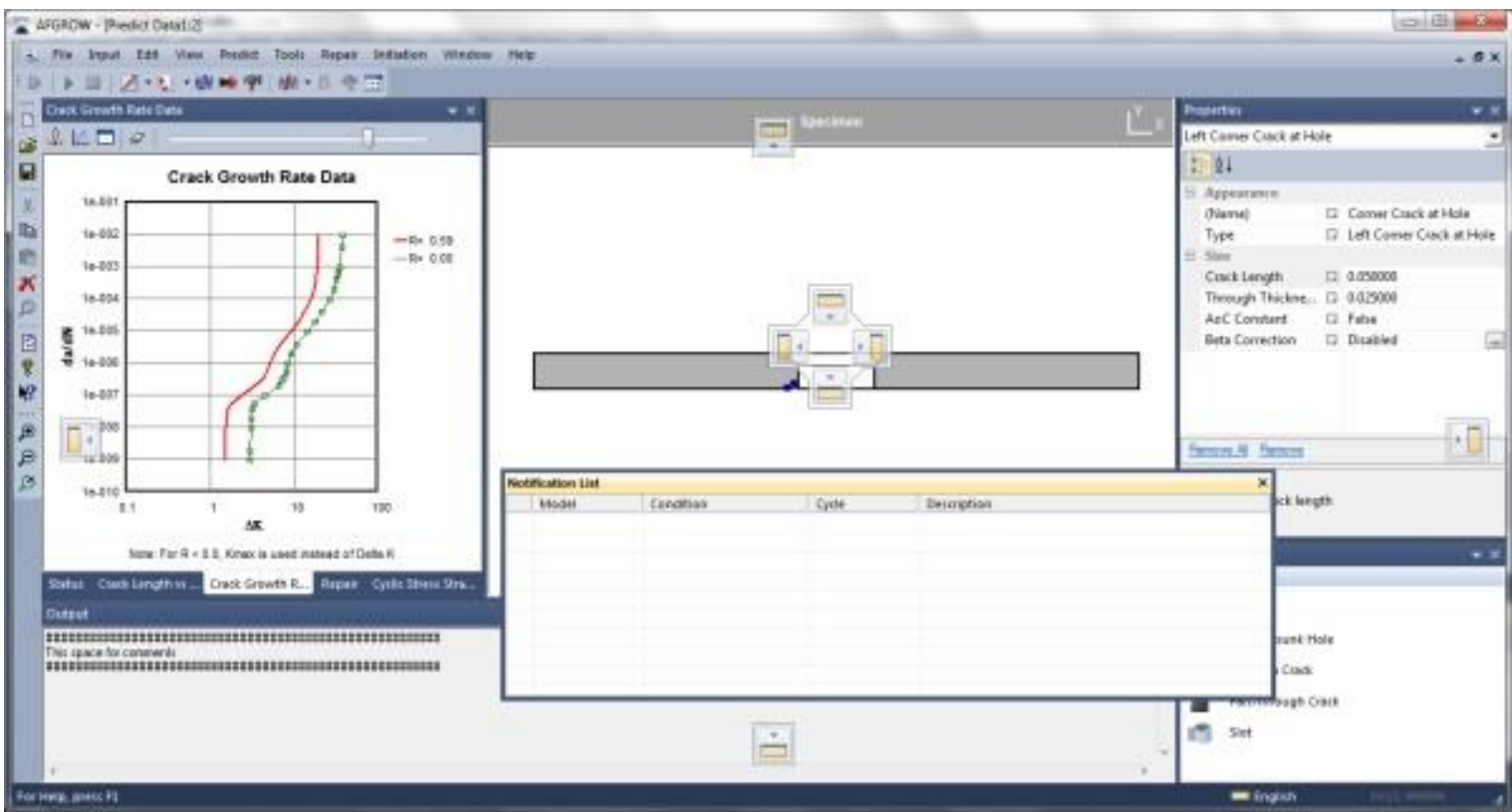
Advantages

- Improved performance
- Better compliance with the C++ language standards
- Compliance with Microsoft Windows authentication and authorization
- Improved run time error checking
- Updated and new GUI controls
- Better OS targeting (Windows 7 or Windows 8 or Windows XP)

Introduced problems

- Random crashes
- Memory leaks
- File access issues (crashes when AFGROW attempts to open, write, or read files)
- Manifestation of preexisting errors
- Screen drawing and dialog problems, issues saving windows, toolbars, and menu states
- Issues creating an AFGROW release that would work on every OS

NEW GUI



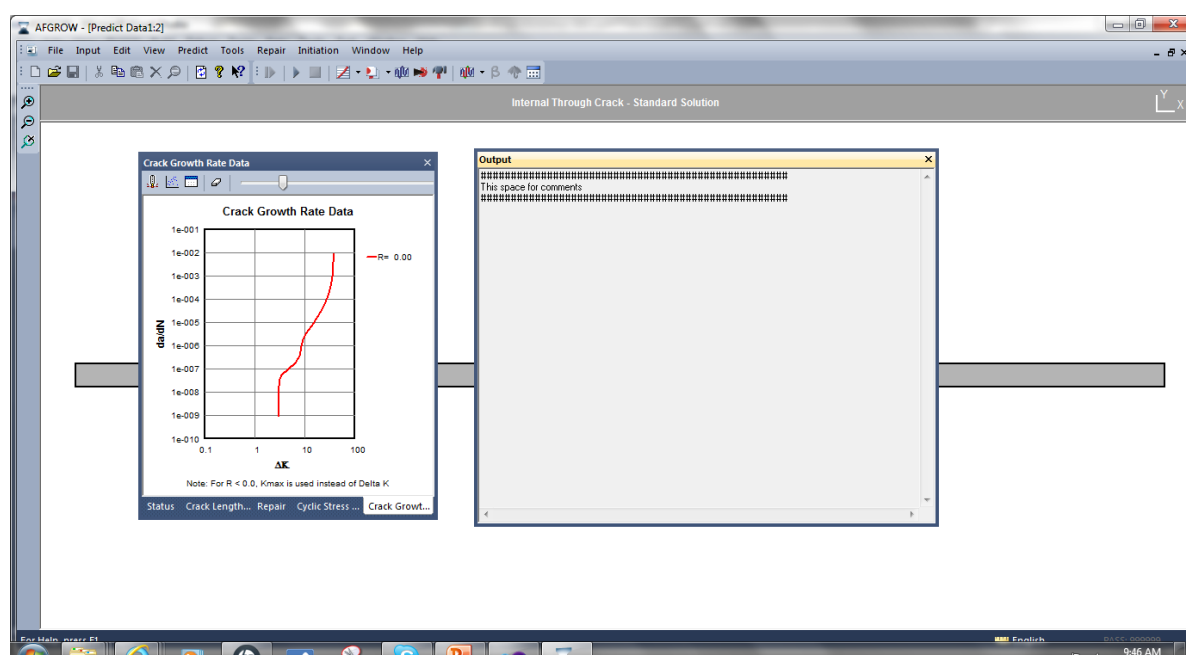
The screenshot displays the AFGROW software interface with the following components:

- Crack Growth Rate Data Graph:** A log-log plot showing crack growth rate (da/dN) on the y-axis (ranging from 1e-110 to 1e-001) versus stress intensity factor (ΔK) on the x-axis (ranging from 0.1 to 100). Two data series are shown: R= 0.50 (red line) and R= 0.00 (green line).
- Specimen Diagram:** A central diagram of a specimen with a central hole and a crack, with various parameters and controls overlaid.
- Properties Panel:** Located on the right, it shows settings for 'Left Corner Crack at Hole', including Appearance, Type, Size (Crack Length, Through Thickne.., AxC Constant), and Beta Correction.
- Notification List:** A table with columns for Model, Condition, Cycle, and Description.
- Output Panel:** Located at the bottom left, it contains a text area for console output.
- Control Panels:** At the bottom, there are buttons for 'Status', 'Crack Length In...', 'Crack Growth R...', 'Repair', and 'Cyclic Stress Str...'.

Output Frame – Copy and Paste



Floating Dockable Views



Advanced Model Properties

The screenshot displays the AFGROW software interface with the following components:

- Menu Bar:** File, Input, Edit, View, Predict, Tools, Repair, Initiation, Window, Help
- Status Panel (Left):**
 - 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
- Specimen View (Center):** A 2D schematic of a specimen with a central crack, labeled 'Specimen'.
- Properties Panel (Right):**
 - Specimen**
 - Appearance: (Name) Specimen
 - Size:
 - Width: 4.000000
 - Thickness: 0.250000
 - Load:
 - Axial: 1.000000
 - Bending: 0.000000
 - Bearing: 0.000000
 - Solution:
 - Type: Two Points
 - Width:** Specifies the specimen width
- ToolBox (Bottom Right):**
 - Hole
 - Countersunk Hole
 - Through Crack
 - Part-Through Crack** (Selected)
 - Slot
- Output Panel (Bottom):**

```

Status  Crack Length v...  Crack Growth ...  Repair  Cyclic Stress Str...

Output
Left Tip C= 0.15  Beta Tension= 1.5422 Beta Compression= 1.5422 R(k)= 0.0000 R(final)= 0.0000  Delta k=1.4821e+001  D()/DN=1.0540e-005
Right Tip C= 0.087789  Beta Tension= 1.6344 Beta Compression= 1.6344 R(k)= 0.0000 R(final)= 0.0000  Delta k=1.2017e+001  D()/DN=5.5830e-006
Left Tip A= 0.19057  Beta Tension= 1.7252 Beta Compression= 1.7252 R(k)= 0.0000 R(final)= 0.0000  Delta k=1.8688e+001  D()/DN=2.3811e-005
Right Tip A= 0.11793  Beta Tension= 1.7411 Beta Compression= 1.7411 R(k)= 0.0000 R(final)= 0.0000  Delta k=1.4837e+001  D()/DN=1.0579e-005
a1/t= 0.7623  a1/c1= 1.2704 a2/t= 0.4717  a2/c2= 1.3433
Max stress  14.000, r = 0.00, 3300 Cycles, Constant amp.: 34, Pass: 34

Terminate - run time : 0 hour(s) 0 minute(s) 9 second(s)
        
```
- Footer:** For Help, press F1 | English | PASS: 999999

Features in the 5.02 Release

- Extended Advanced Model Solution for Corner Cracks at a Hole to Handle Small Cracks
- Updated Solution for a Single Through Crack at a Hole Under Bearing Load
- Improved Offset Correction for Cracks at Holes Under Bearing Load
- Spectrum Tool – Beta version, available to download
- Warning Messages When K-Solution Limits are Exceeded
- Expanded Input Table Size (virtually unlimited)
- Improved COM and Plug-In Interface
- New GUI
- Corner Crack at a Countersunk Hole Solution – Axial Load Only
- Beta Sub-R
- Beta Correction Capability for Advanced Models – Works only for the corner crack(s) at hole
- Bug fixes

Planned Features That did not Make the 5.02 Release

- Multi-Channel spectrum format in AFGROW – can be added in the next AFGROW upgrade/service pack ?
- Ability to replicate results from previous versions (back to Version 5.01) –moved to the release 5.03
- Option to save input file(s) with retardation state data for later restart - moved to release 5.03
- Corner crack at a countersunk hole solution – Bending - will be added in the 5.02.04 AFGROW upgrade/service pack – 75%
- Corner crack at a countersunk hole solution – Bearing - will be added in the next AFGROW upgrade/service pack or release 5.03, assuming that data is acceptable
- Beta Correction Capability for the Advanced Models – Add ability to work for the Through Crack(s) at Hole - will be added in the 5.02.04 AFGROW upgrade/service pack

Post Release Applicability Issues

- Extended Advanced Model Solution for Corner Cracks at a Hole to Handle Small Cracks



- 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 :

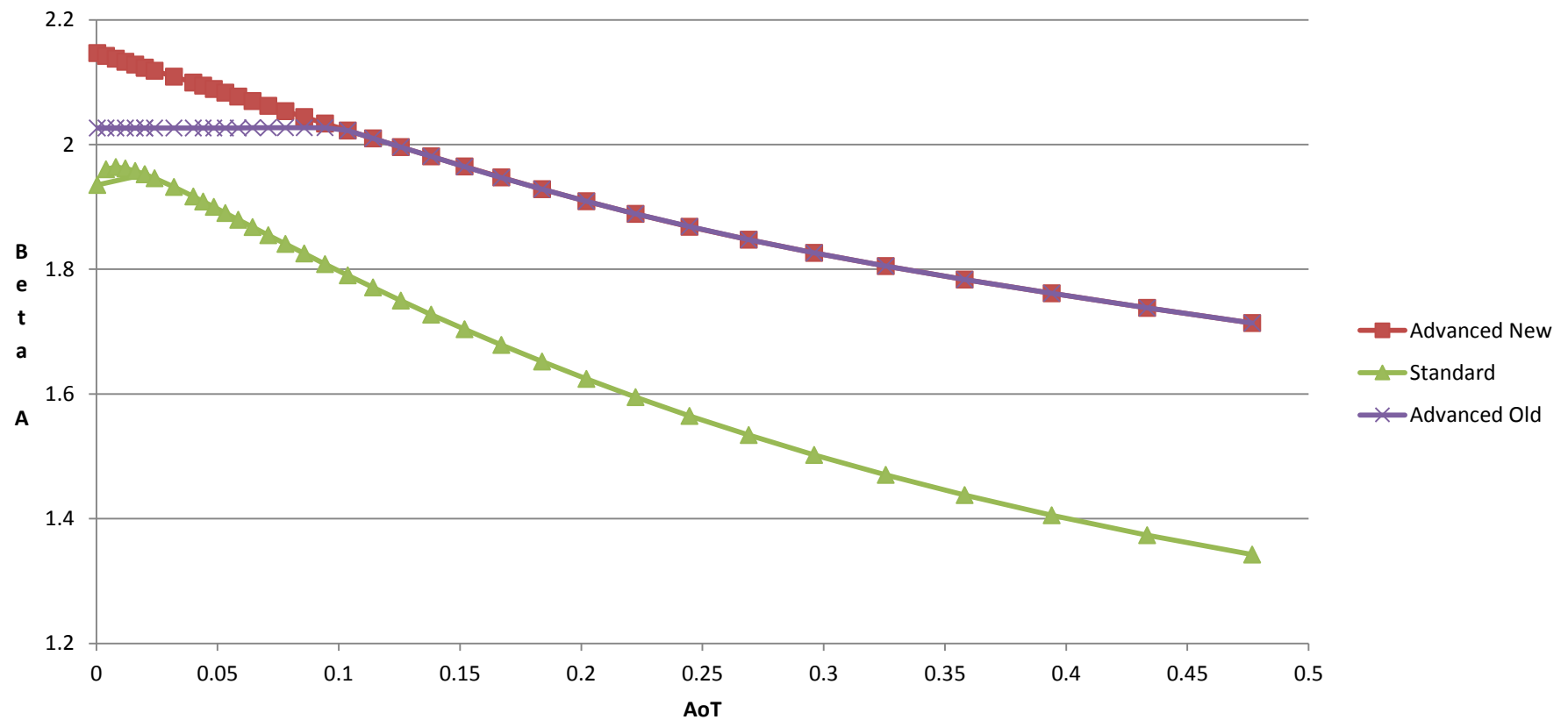
$$\beta = 1.122 K_t \frac{2}{\pi}$$

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

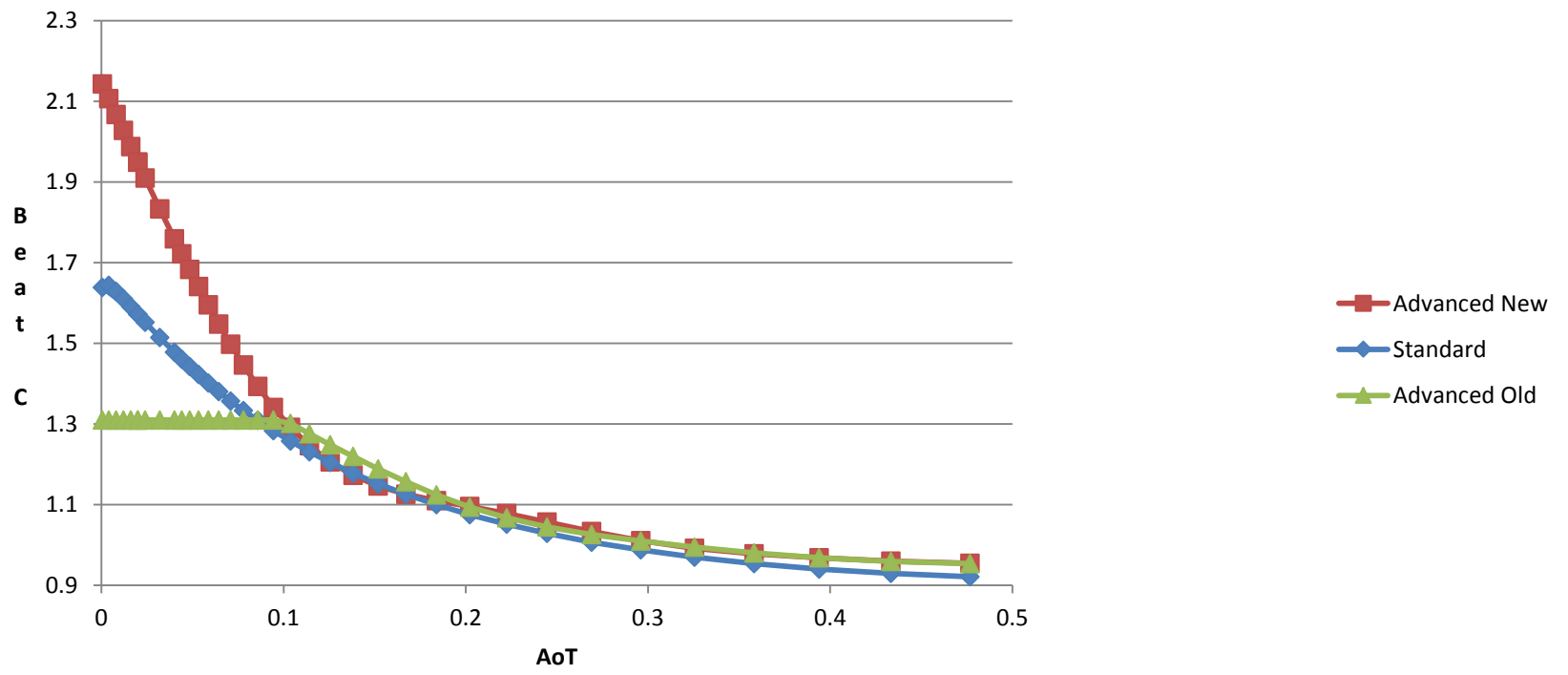
Works only for the 2 points models, does not work for the multipoint model

- Corner Crack(s) at a Countersunk Hole Solution

Advanced Corner Cracked Hole Model (Small Crack Beta Values)



Advanced Corner Cracked Hole Model (Small Crack Beta Values)



Extended Advanced Model Solution for Corner Cracks at a Hole

a1/a2 less than 0.1 or greater than 10 is outside of the solution bounds, and will cause increasing errors as these limits are exceeded

For a the double corner cracks, stress intensity solutions were calculated for the following combinations of geometric parameters:

R/t: 0.1, 0.111, 0.125, 0.1428, 0.1667, 0.2, 0.25, 0.333, 0.5, 0.667, 0.75, 0.8, 1.0, 1.25, 1.33, 1.5, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0

a1/c1, a2/c2: 0.1, 0.111, 0.125, 0.1428, 0.1667, 0.2, 0.25, 0.333, 0.5, 0.667, 0.75, 0.8, 1.0, 1.25, 1.33, 1.5, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0

a1/t, a2/t: 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95, 0.99

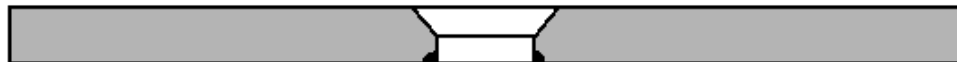
Countersunk Hole Solution

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

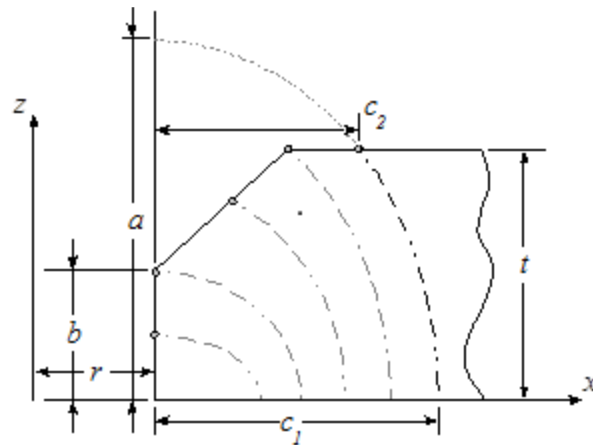
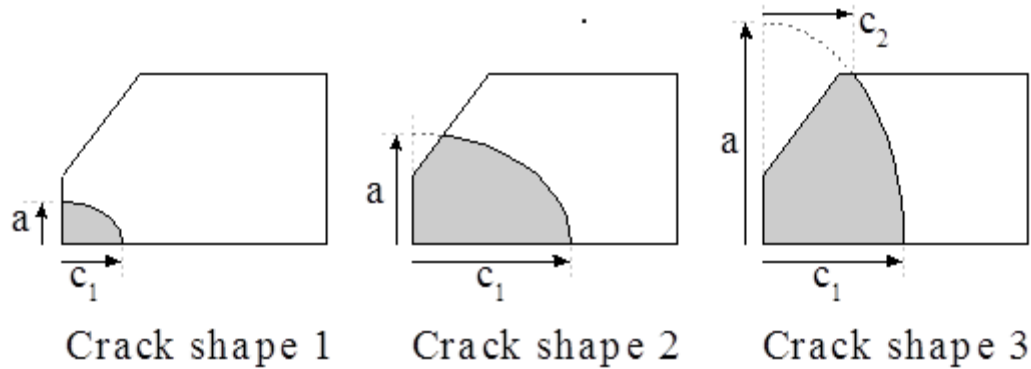
- Centered or offset hole with single corner crack



- Centered hole with symmetric double corner crack



Countersink Dimensions



Countersunk Solution Beta Comparison with APES Report

Case	a/c	a/t	r/t	b/t	% Difference	Beta c	Beta a
1	0.5	0.025	0.5	0.05	3.254657	1.67236	
2	0.5	0.025	1	0.05	1.949294	-0.98587	
3	0.5	0.025	2	0.05	1.509914	-2.51442	
4	0.5	0.125	0.5	0.25	-2.19182	5.962669	
5	0.5	0.125	1	0.25	-2.81495	1.001557	
6	0.5	0.125	2	0.25	-3.90295	-3.92395	
7	0.5	0.25	0.5	0.5	0.707881	4.732164	
8	0.5	0.25	1	0.5	1.693459	1.488978	
9	0.5	0.25	2	0.5	0.753314	-0.94554	
10	1	0.025	0.5	0.05	3.227014	2.431118	
11	1	0.025	1	0.05	2.273369	-1.10244	
12	1	0.025	2	0.05	2.6051	-1.41645	
13	1	0.125	0.5	0.25	-2.60347	5.958412	
14	1	0.125	1	0.25	-3.22433	1.242293	
15	1	0.125	2	0.25	-5.70114	-3.91733	

Case	a/c	a/t	r/t	b/t	% Difference	
					Beta c	Beta a
16	1	0.25	0.5	0.5	0.298298	7.716755
17	1	0.25	1	0.5	0.836336	4.94164
18	1	0.25	2	0.5	0.629744	1.753479
19	2	0.025	0.5	0.05	4.88457	4.619894
20	2	0.025	1	0.05	1.720744	2.148594
21	2	0.025	2	0.05	1.146744	1.682437
22	2	0.125	0.5	0.25	1.329535	8.407049
23	2	0.125	1	0.25	-1.09421	2.889405
24	2	0.125	2	0.25	-3.89117	-3.20755
25	2	0.25	0.5	0.5	2.699964	12.90863
26	2	0.25	1	0.5	3.065508	9.261383
27	2	0.25	2	0.5	1.364754	4.16409
28	0.2	0.25	0.5	0.5	-14.3891	81.28874
29	0.2	0.025	1	0.05	-57.609	12.63421
30	0.2	0.025	2	0.05	-55.1998	12.37581
31	0.2	0.125	0.5	0.25	-66.9102	14.88731
32	0.2	0.125	1	0.25	-67.2151	12.78878
33	0.2	0.125	2	0.25	-64.3895	11.59074
34	0.2	0.25	0.5	0.5	-58.4998	15.44254
35	0.2	0.25	1	0.5	-63.5382	13.34377
36	0.2	0.25	2	0.5	-65.2845	13.15974

Countersunk Hole Solution

Applicability

- stress intensity solutions were calculated, and are valid for the following combinations of geometric parameters:

R/t: 0.1, 0.25, 0.5, 0.667, 1.0, 1.2, 1.5, 2.4

B/t: 0.05, 0.25, 0.5

a/c: 0.5, 0.667, 0.75, 1.0, 1.5, 2.0, 5.0

The geometrical parameters that are far outside of the boundaries can produce the invalid results

- The countersunk with the depth less than 50% of thickness has no effect on the total life of the crack at hole

AFGROW Minor Releases

5.02.02.18, Released: May 15, 2014

- Fixed the “SHIFT+F1 Help” in AFGROW. SHIFT+F1 Help invokes a special “Help mode” in which the cursor turns into a Help cursor. The user can then select a visible object in the user interface, such as a menu item, toolbar button, or window. This action opens the appropriate help topic for the selected item.
- Made additional updates to the AFGROW Help content.
- Fix a bug when AFGROW would crash when the "stop crack at part through transition" propagation preference was selected for the advanced models.
- Removed the outdated limit of 30 growth rates that was shown in the tabular lookup dialog.
- Fixed a bug where user could not set the bending constraint for the slot case
- Fixed an issue adding a corner crack to the hole with a slot.
- Fixed an issue where AFGROW would crash when reading a dax file with the tabular lookup data that not include data for R=0.
- Fixed an issue where AFGROW would randomly crash when “countersunk crack at hole” and “output to file” options were selected.
- Added support for Office 2013

AFGROW Minor Releases

5.02.03.18, Released: July 25, 2014

- AFGROW crashed when the tabular lookup model was set using COM with more than 2 R-values
- Bug fix for a crash in the advanced interface when the bearing load fraction was > 0 for a double, corner cracked hole.
- AFGROW would send output data to the screen for advanced interface when the option "output to the screen" was turned off.

AFGROW Bug and Minor Issue List

Issues Queries Administration

Afgrow 5.2 release Issues

[Return To List](#)











[Save Layout](#)

1  10  27 

[Add New Issue](#)

Relevant To You Assigned To You Owned By You Created By You All Issues Hidden Issues

[Export to Excel](#) [Export to Word](#)

Status	Issue (click title to view details)	Category	Created By	Owner	Assigned	Project Stage	Priority	Date Created
	Add ability to set constrained on the specimen, required to support edge crack and slot models	Input-Output	alitvinov	alitvinov	alitvinov	Release 5.2.3	Medium	2014/09/08
	Impossible to set beta correction for the Advanced Model through crack at hole	Advanced Models	alitvinov	alitvinov	alitvinov	Release 5.2.3	High	2014/09/08
	AFGROW can not open the pl2 file using the "View plots in excel" option	Input-Output	alitvinov	alitvinov	alitvinov	Release 5.2.1	High	2014/09/08
	Plugin does not output the string parameter correctly, instead it prints the number	Plugin	alitvinov	alitvinov	alitvinov	Release 5.2.3	High	2014/08/29
	AFGROW Plugin issue deleting multiple cracks	Plugin	alitvinov	alitvinov	alitvinov	Release 5.2.2	Medium	2014/08/27
	Afgrow crashes when Tabular lookup model set using COM with mire then 2 Rs	COM Interface	alitvinov	alitvinov	alitvinov	Release 5.2.1	High	2014/07/23
	Crash in Advanced Double Crack when bearing is > 0	Advanced Models	alitvinov	alitvinov	alitvinov	Release 5.2.2	High	2014/07/23
	AFGROW outputs to the screen in advanced solution even if "output to the screen" turned off	GUI	alitvinov	alitvinov	alitvinov	Release 5.2.1	Medium	2014/07/23
	Advanced Model Crashes when "stop crack at part through transition" is selected	Advanced Models	alitvinov	alitvinov	alitvinov	Release 5.2.1	High	2014/05/05
	tabular lookup dialog lists wrong maximum number of the rates	GUI	alitvinov	alitvinov	alitvinov	Release 5.2.1	Low	2014/04/28

1 2 3 4 ... Page size: 10

38 items in 4 pages

AFGROW Bug and Minor Issue List

- Add ability to set the in-plane bending constraint on the specimen - required to support edge crack and slot models
- Can't use beta correction for the Advanced Model through crack at hole
- AFGROW can not open certain pl2 files with advanced model results using the "View Plots in Excel" option
- Plug-In does not output the string parameter correctly, instead it prints the number
- AFGROW Plug-In sometimes crashes deleting multiple cracks
- Add ModelErrorCheck function to handle non-trivial error check of model properties
- Set axial stress fraction to 1 after Advanced corner crack transition
- Add a checkbox to manage "Data Save" warning during Afgrow closeout
- New Carlson/Andrews bug

Spectrum Tool

Spectrum Manager - C:\Users\alex\Documents\Visual Studio 2010\Projects\AfgrowDevelopment\Targets\dfstaf.sp3

Edit Preview Spectrum View



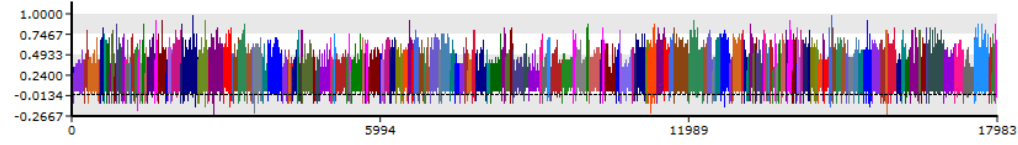
Spectrum Preview

Sub Spectrums

- ▲ Falstaff
 - ▲ Sub Spectra
 - Flight 1
 - Flight 2
 - Flight 3
 - Flight 4
 - Flight 5
 - Flight 6
 - Flight 7
 - Flight 8
 - Flight 9
 - Flight 10
 - Flight 11
 - Flight 12
 - Flight 13
 - Flight 14
 - Flight 15
 - Flight 16
 - Flight 17
 - Flight 18
 - Flight 19

#	cycle	Max	Min	Cycles	Sub Spectrum Name
14	22	0.3462	0.1828	1	Flight 1
15	23	0.3054	0.1828	1	Flight 1
16	24	0.3462	0.1011	1	Flight 1
17	25	0.2236	0.1011	2	Flight 1
18	27	0.2645	0.1011	1	Flight 1
19	28	0.2236	0.1011	1	Flight 1
20	29	0.3462	0.1419	1	Flight 1
21	30	0.2645	0.1419	1	Flight 1
22	31	0.2645	0.1011	1	Flight 1
23	32	0.2236	0.1011	2	Flight 1
24	34	0.2645	-0.0624	1	Flight 1
25	35	0.0193	-0.0624	1	Flight 1

Chart



PropertiesWindow

A-Z

▲ Spectrum

Title	Falstaff
SubSpectrum Label	Flight
Description	
Hours Per Pass	1

▲ Statistics

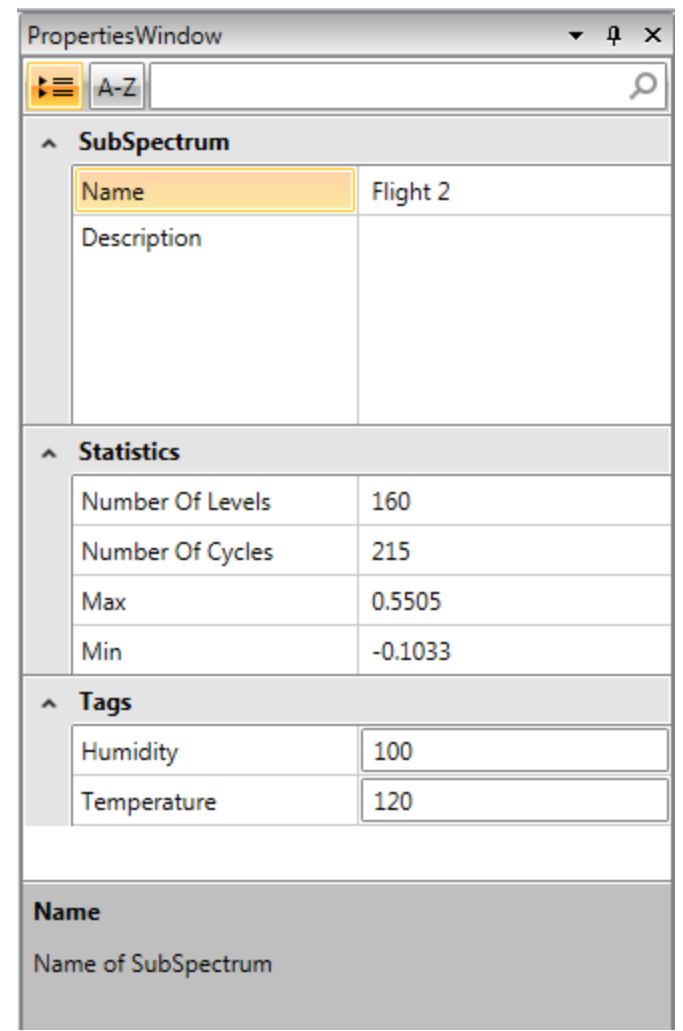
Number Of Levels	15674
Number Of Cycles	17983
Max	1
Min	-0.2667

Properties Errors

Falstaff

Spectrum Tool Overview

- Visual spectrum design
- Spectrum level reordering
- Sub-spectra organized in any user-defined sequence
- Sub-spectra may be placed in the sequence more than once
- Sub-spectra may be re-ordered in the sequence
- Spectrum statistics at a glance
- Exceedance curve
- Sub-spectra tagging for future analysis
- Synchronized data views



The screenshot shows a 'PropertiesWindow' with the following sections:

- SubSpectrum:** A table with columns 'Name' and 'Description'. The 'Name' column contains 'Flight 2'.
- Statistics:** A table with the following data:

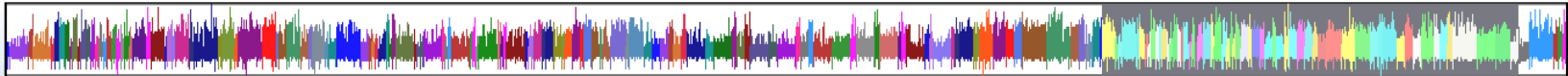
Number Of Levels	160
Number Of Cycles	215
Max	0.5505
Min	-0.1033
- Tags:** A table with the following data:

Humidity	100
Temperature	120
- Name:** A label 'Name' with a description 'Name of SubSpectrum' below it.

Spectrum Tool – Synchronized Views

Spectrum Manager - C:\Users\alex\Documents\Visual Studio 2010\Projects\AfgrowDevelopment\Targets\dfstaf.sp3

View

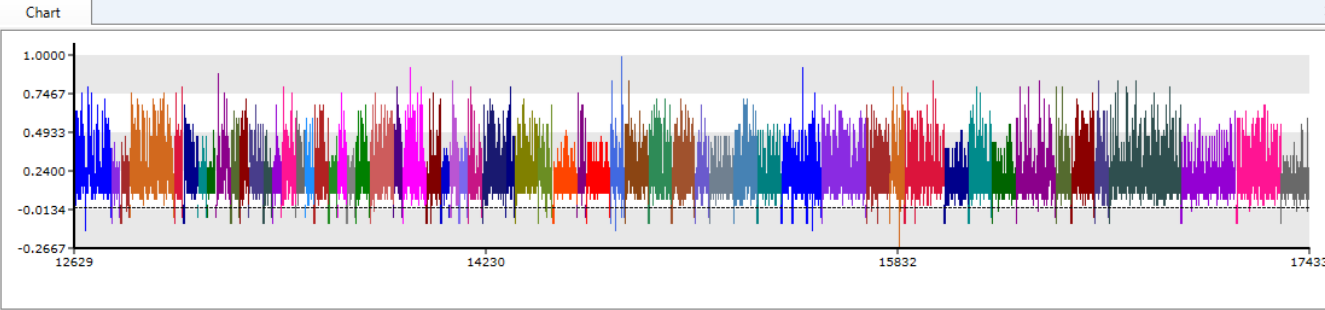


Spectrum Preview

#	cycle	Max	Min	Cycles	Sub Spectrum Name
10848	12629	0.2236	0.0193	1	Flight 136
10849	12630	0.3054	0.1419	1	Flight 136
10850	12631	0.6322	0.2645	1	Flight 136
10851	12632	0.4279	0.2236	1	Flight 136
10852	12633	0.4279	0.0602	1	Flight 136
10853	12634	0.1828	0.0602	2	Flight 136
10854	12636	0.2236	0.0602	1	Flight 136
10855	12637	0.3462	0.1828	1	Flight 136
10856	12629	0.2054	0.1011	1	Flight 136

SubSpectrums

Chart



PropertiesWindow

Spectrum

Title: Falstaff
 SubSpectrum Label: Flight
 Description:
 Hours Per Pass: 1

Statistics

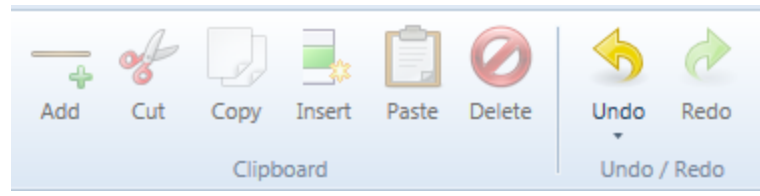
Number Of Level: 15674
 Number Of Cycle: 17983
 Max: 1
 Min: -0.2667

Properties Errors

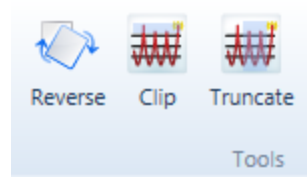
Falstaff

Spectrum Tool - Capabilities

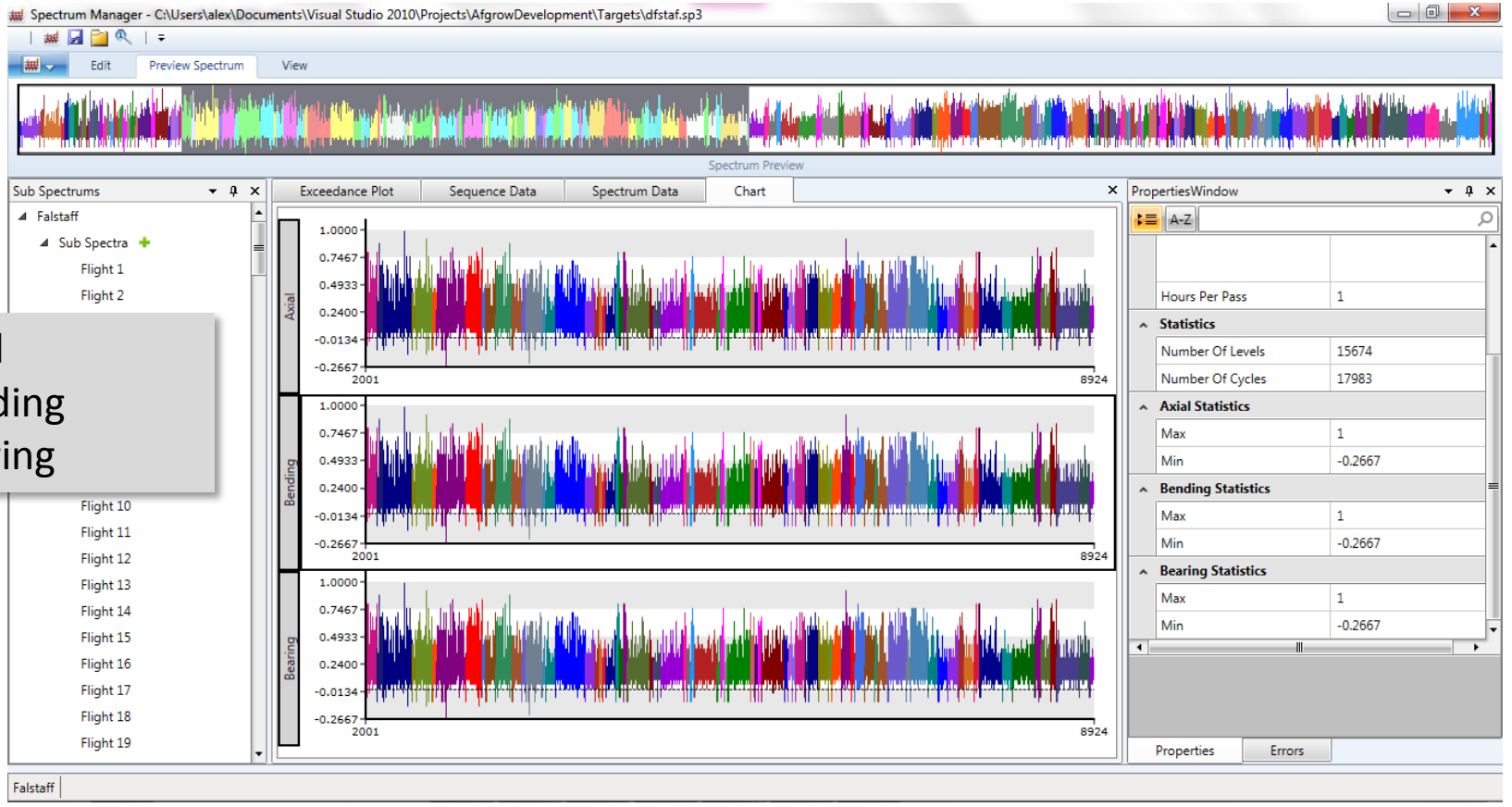
- Copy/Paste/Cut/Insert to and from Excel
- Undo and Redo



- Clipping
- Truncation
- Spectrum reversal (Min with Max * -1, flip if necessary) requested by Northrop



Spectrum Tool Supports Multi Channel Loading



- Axial
- Bending
- Bearing

Multi Channel Loading Issue

The goal of this new capability is to allow the option for the axial, bending, & bearing stress fractions to change for each stress level as may be expected in reality. For general use, there are many ways to manage 3-channel spectra.

One possible way would be to use a single channel spectrum that has been cycle counted directly from flight test data, and break out the 3 load cases based on some estimate of the load fractions for each level based on the users best information. This would be very tedious, but the use of the XML file format could be used to identify load cases and make it possible to help to automate the process.

Spectrum Tool Distribution

- Released as a beta version
- Available for download from the AFGROW website
- Can be used by anyone with valid 5.02 license
- Draft of the manual is available at www.afgrow.net for download
- Video tutorial is available at www.youtube.com/afgrow

Questions