AFGROW BEASY Integration for Improved Life Prediction

Ryan Butchers, Sharon Mellings, Tom Curtin, John Baynham and Robert Adey
CMI BEASY

Helping Engineers Control Corrosion & Cracks

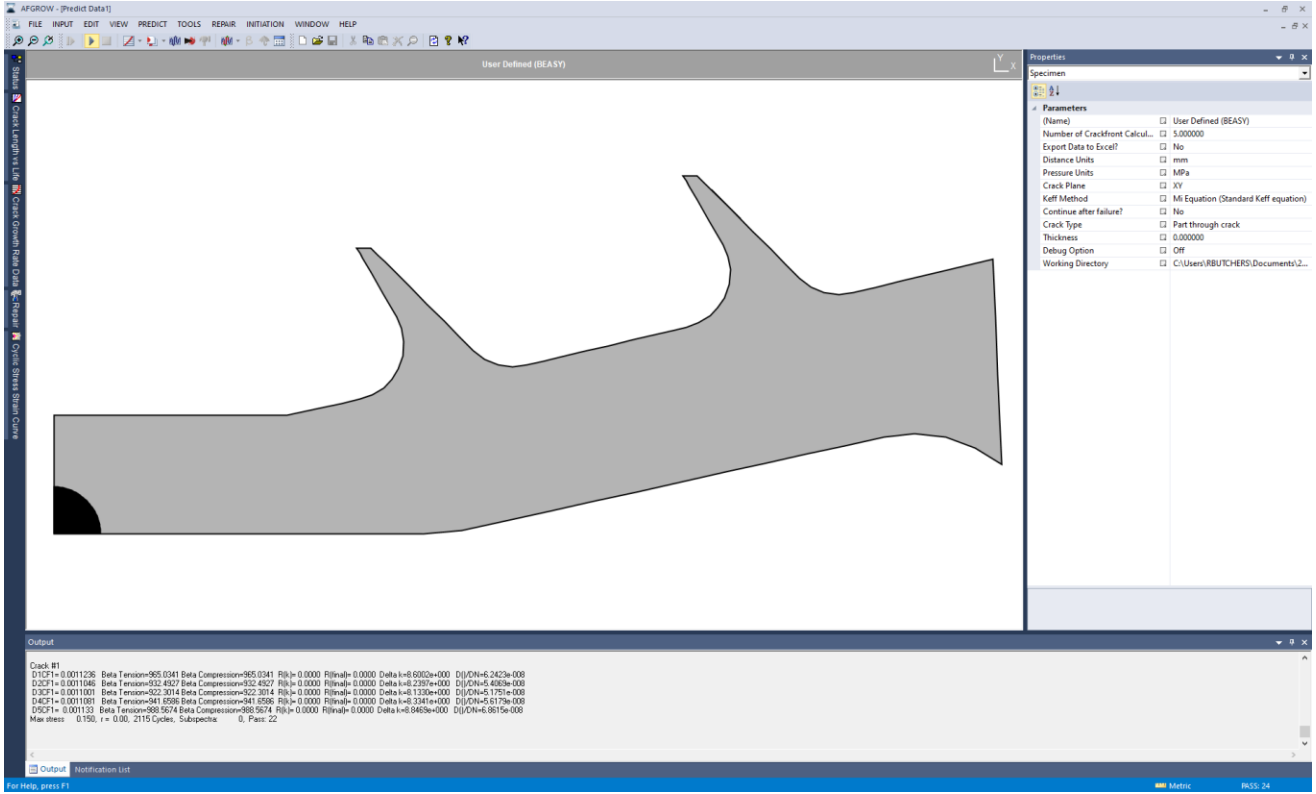
BEASY SOFTWARE & SERVICES

Overview

- Introduction
  - BEASY Plugin for AFGROW
- Motivation
  - More realistic crack growth simulations
  - Creating a framework to support environmental assisted cracking and new advanced manufacturing methods
- BEASY Crack Simulation Capabilities
- Integration with AFGROW
  - General User Created Models
  - Plugin Library Type Models Example Application
- Summary

Introduction

- The BEASY plugin for AFGROW has been designed to expand the capabilities of AFGROW
- It provides a link to the more advanced crack growth modelling available in BEASY
  - This greatly expands the number of models which can be analysed
  - And provides access to more advanced fracture mechanics capabilities and techniques

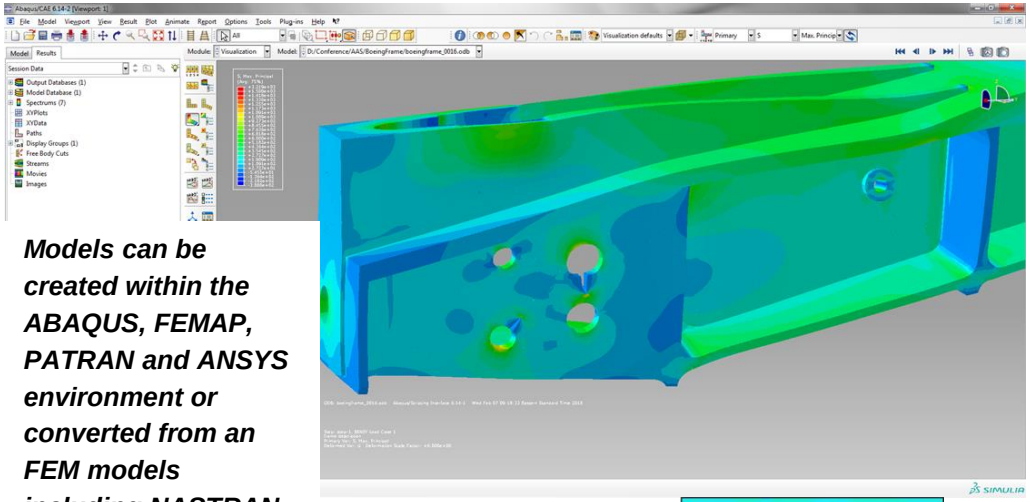


Plugin Provides Advanced Capabilities

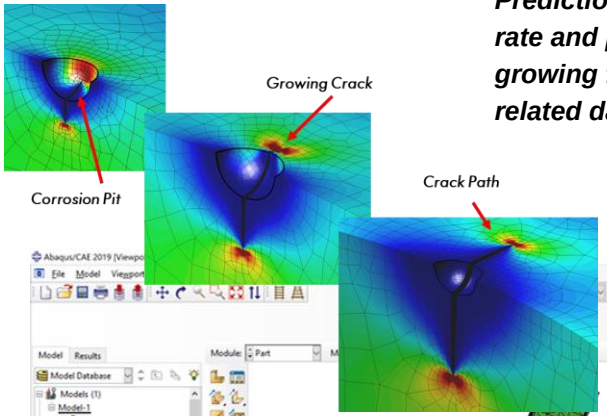
Integration with BEASY allows for a wide range of advanced capabilities, including:

- Full 3D analysis of actual structural part geometries
- Mixed mode analysis (K_I,K_{II},K_{III}) allowing the assessment of crack turning
- Tracking crack growth distance at multiple positions along the crack front
- Ability to allow cracks to split into multiple crack fronts

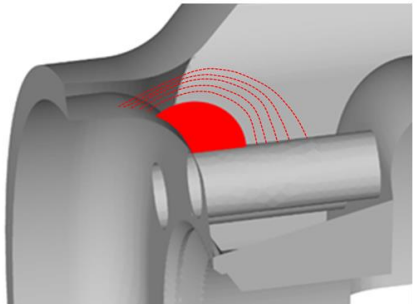
Stress Intensity Factor (SIF) and Crack Path Solutions from Realistic Models can be used for Structural Lifing

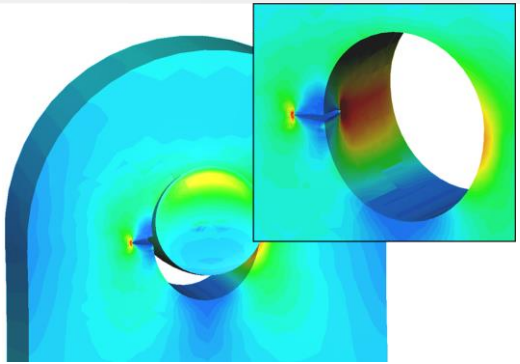


Models can be created within the ABAQUS, FEMAP, PATRAN and ANSYS environment or converted from an FEM models including NASTRAN

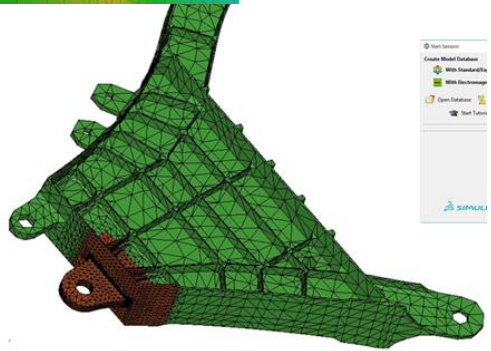


Prediction of the growth rate and path of a crack growing from a corrosion related damage



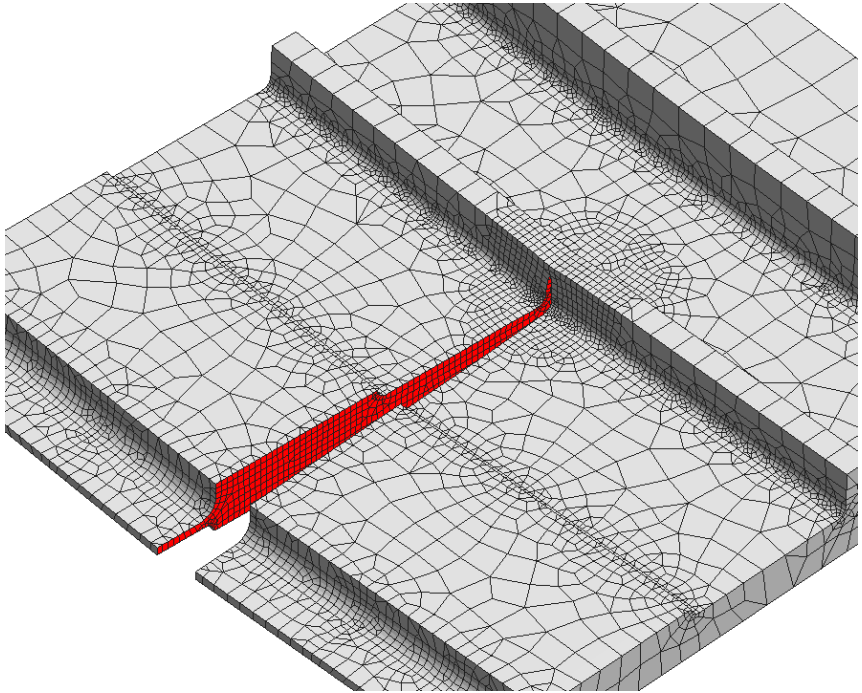


Sub models of critical areas can be created from large scale FE models including the capability to derive residual stress fields from non-linear FEM solutions.

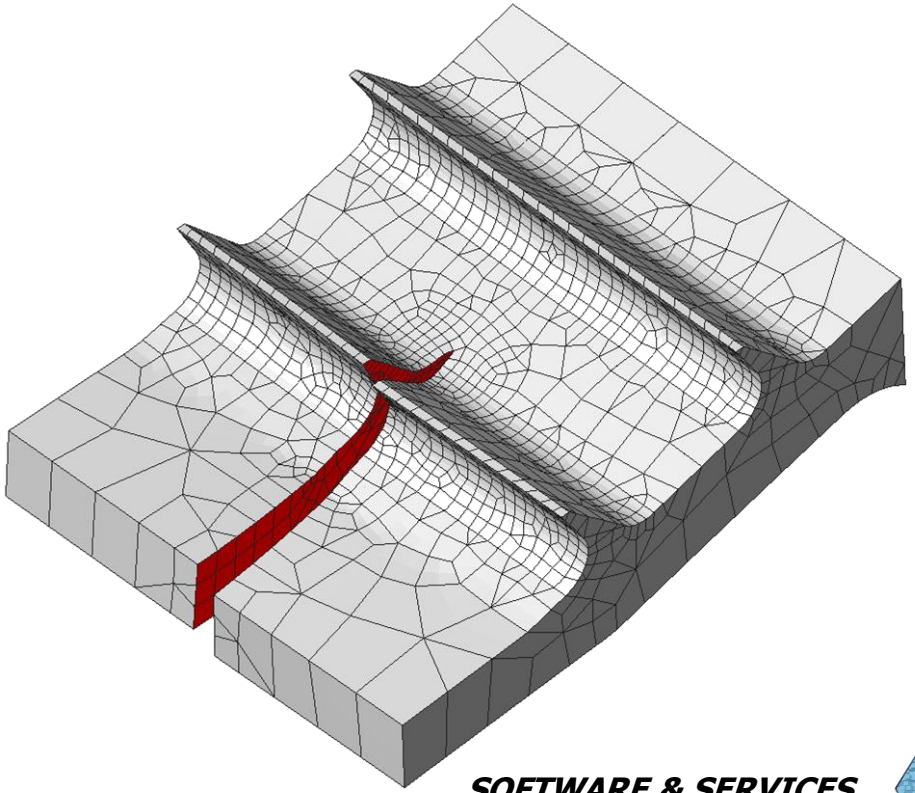


Advanced Geometries

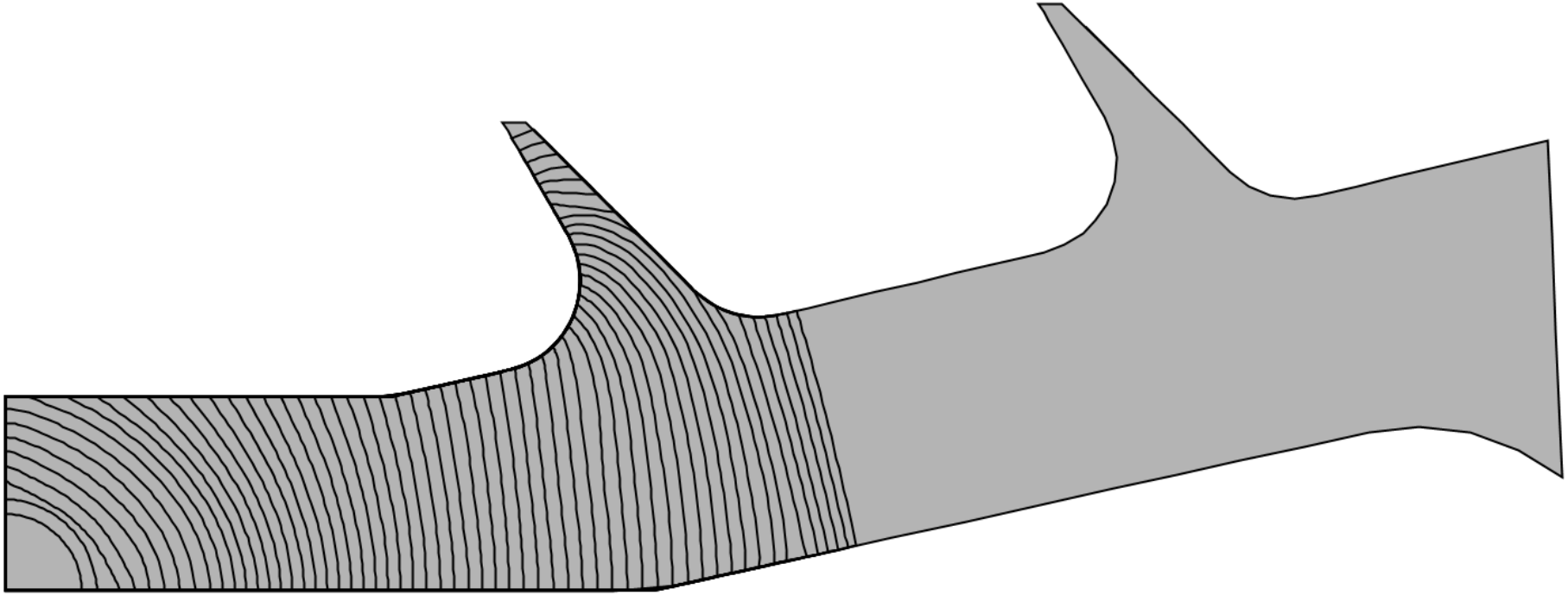
Machined Stiffener



Cooling Fin



Predicted Crack Fronts

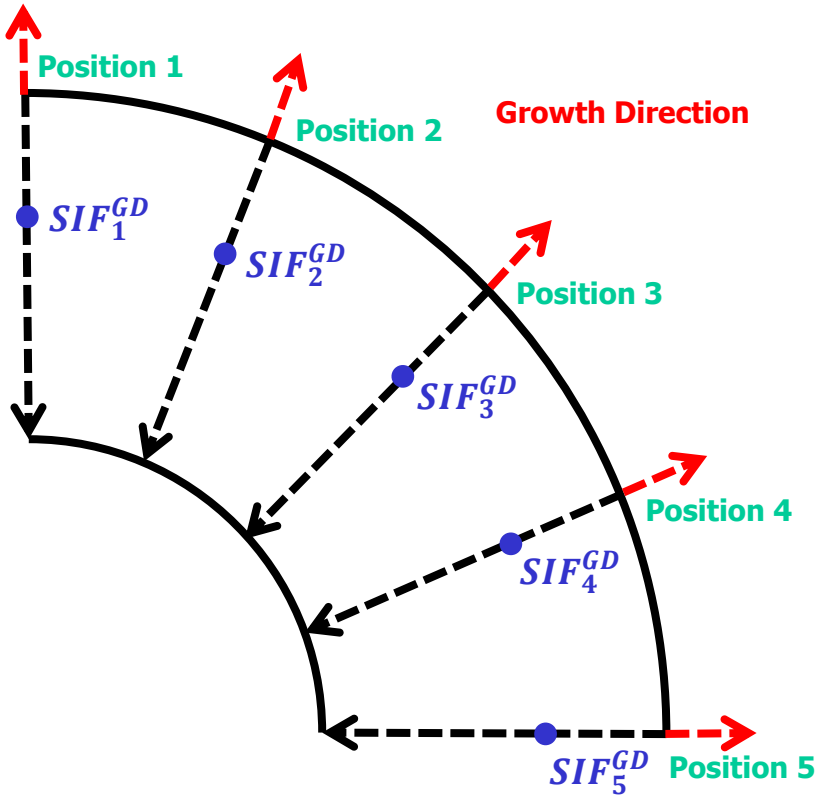


Stress Intensity Factor (SIF) at Multiple Positions along the Crack Front

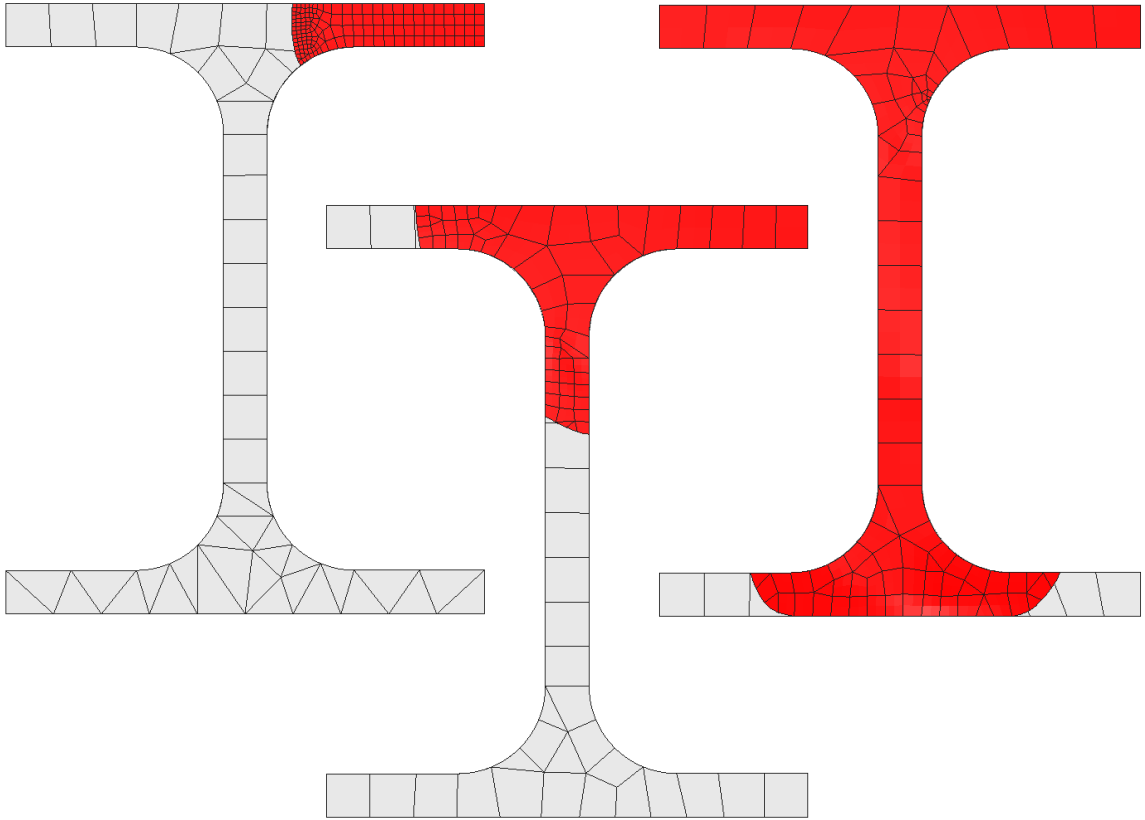
Mode 1,2 and 3 SIF values are:

- **Calculated at multiple positions along the crack front (using J-integral techniques)**
  - The number of calculation points can be defined in the plugin, with a user defined parameter
- **And interpolated at a number of growth distances between BEASY crack growth increments**
  - The number of SIF calculations performed between increments can be determined in the "Growth Increment" tab in "Predict → Preferences"

This provides a more accurate representation of crack shape evolution which is controlled by the SIF solution along the crack front. With this method the crack shape is not constrained to a simplified geometric curve fit



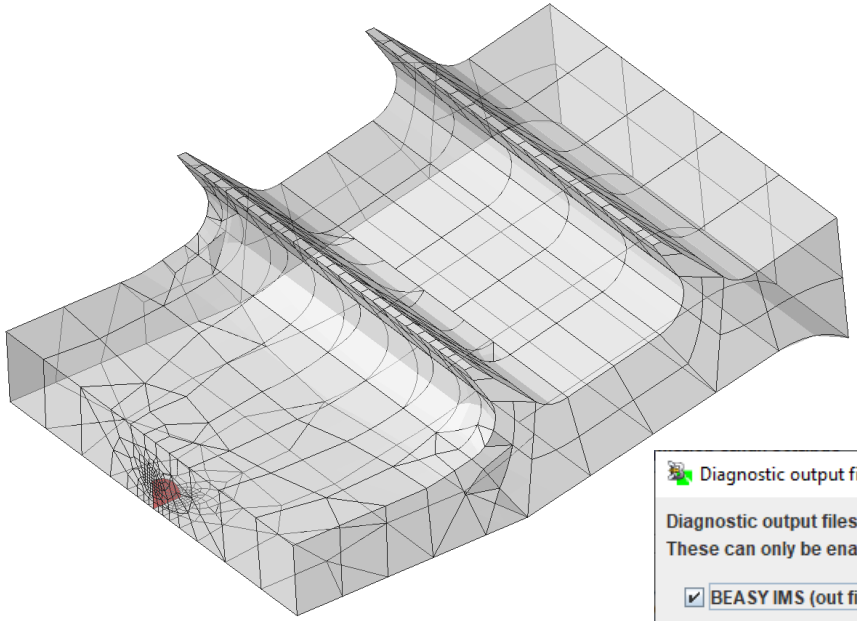
Multiple Crack Fronts



The ability to track multiple crack fronts allows for a wide range of parts to be analysed

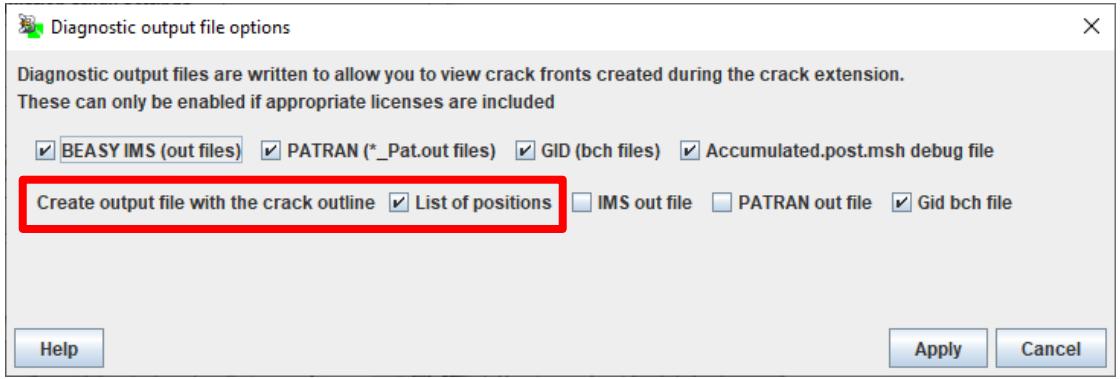
SIFs are calculated at multiple positions along each crack front to determine their growth and shape

Building AFGROW Compatible BEASY Models



To create an AFGROW compatible model, simply perform BEASY crack growth simulation using BEASY version 21.02.005 or later.

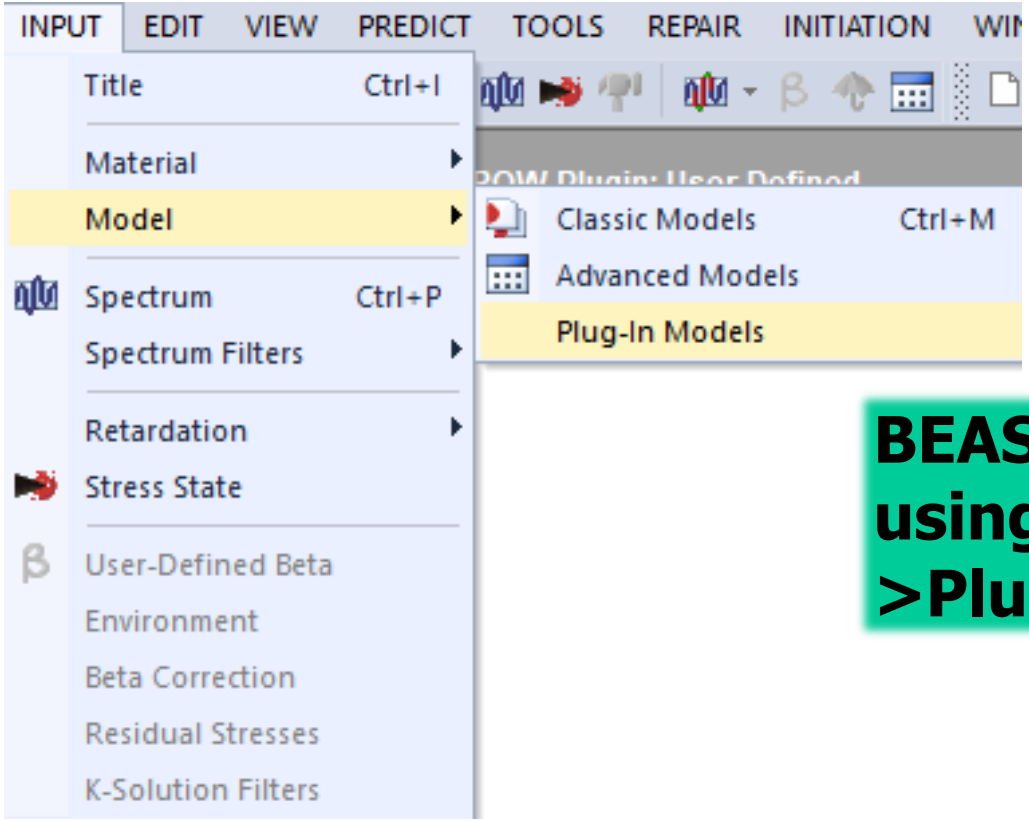
However, in order to see the crack outline in AFGROW, you need to select the option highlighted in the figure below.



The software can be used in two ways

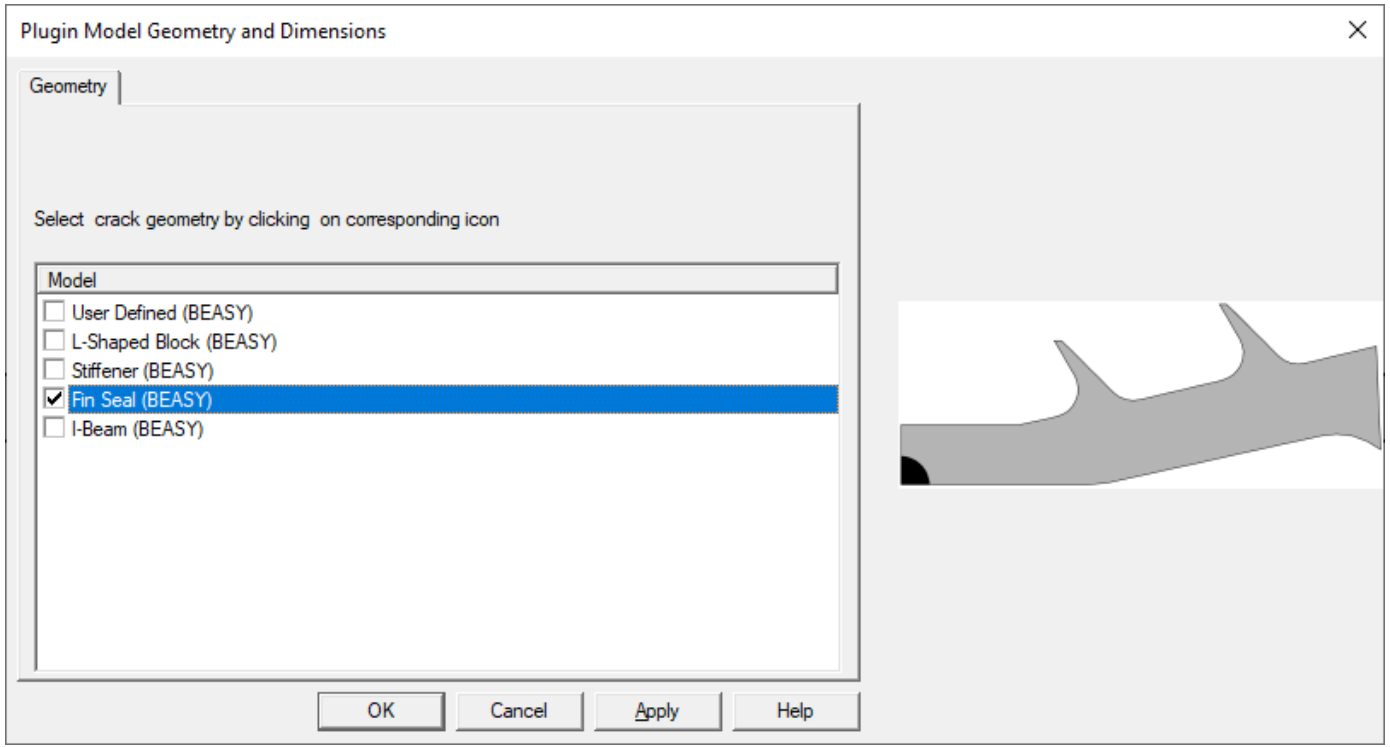
- General User Created Models
  - This allows the user to create their own models. These would need to be run using a full BEASY crack growth simulation
- Plugin Library Type Models
  - In this case the SIF and crack path have been encapsulated into Plugin models which can then be used by AFGROW to perform the Life prediction

Select a Model



BEASY models can be found using "INPUT->Model->Plug-In Models"

Select a Model



Select either a user defined model or one of the plugin models available

Parameters

User Defined Parameters

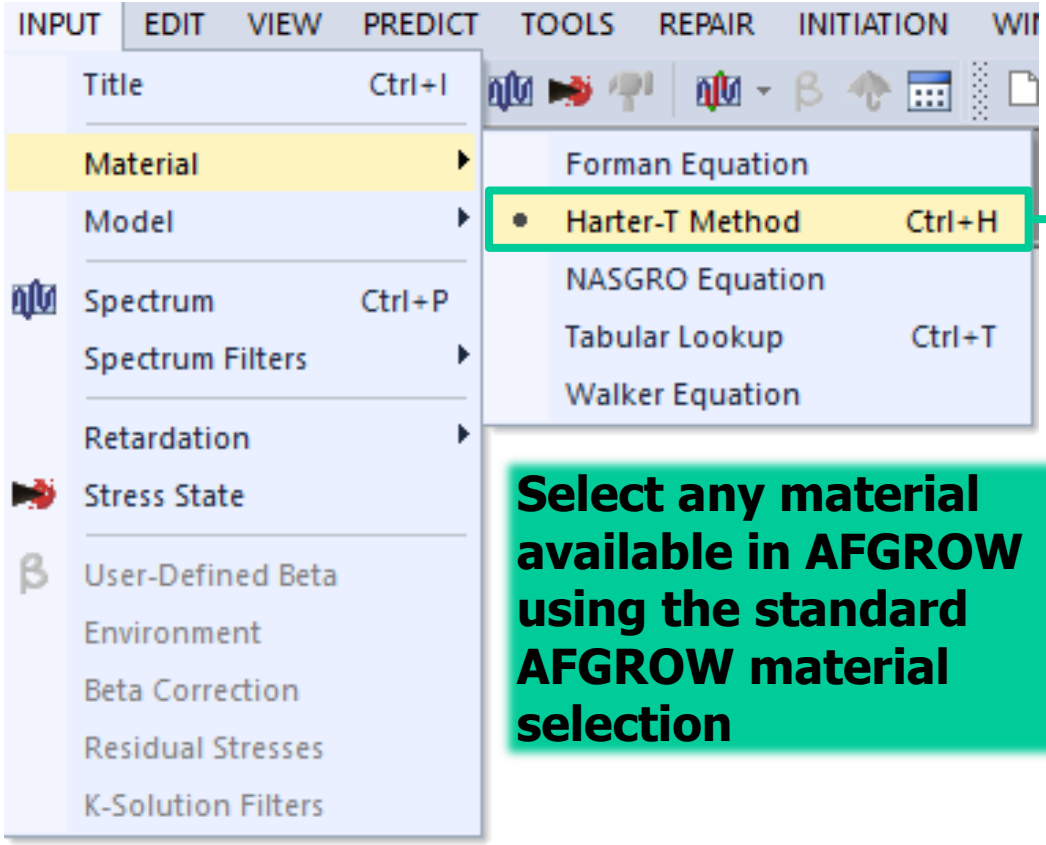
Parameters	
(Name)	User Defined (BEASY)
Number of Crackfront Calcul...	5.000000
Export Data to Excel?	No
Distance Units	m
Pressure Units	MPa
Crack Plane	XY
Keff Method	Mi Equation (Standard Keff equation)
Continue after failure?	No
Crack Type	Part through crack
Thickness	0.000000
Debug Option	Off
Working Directory	

Pre Defined Parameters

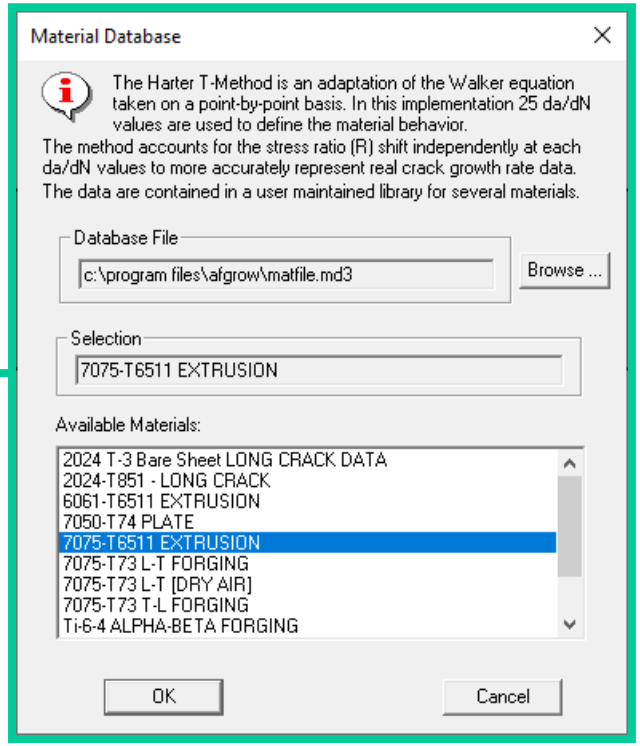
Parameters	
(Name)	Fin Seal (BEASY)
Number of Crackfront Calcul...	5.000000
Export Data to Excel?	No
Keff Method	Mi Equation (Standard Keff equation)
Continue after failure?	No
Debug Option	Off
Working Directory	

Some parameters can be customised to the right of the screen

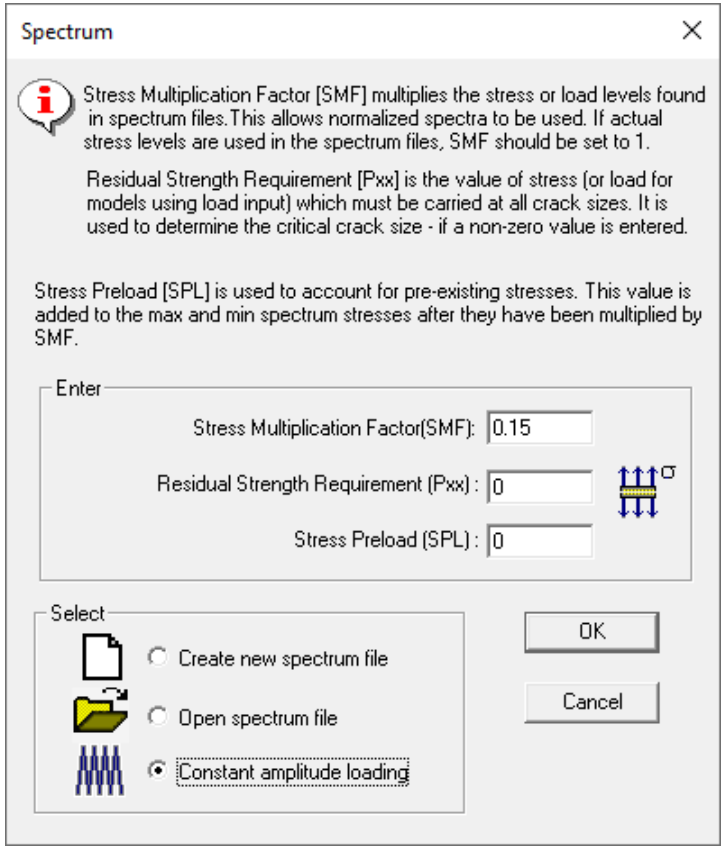
Select a Material

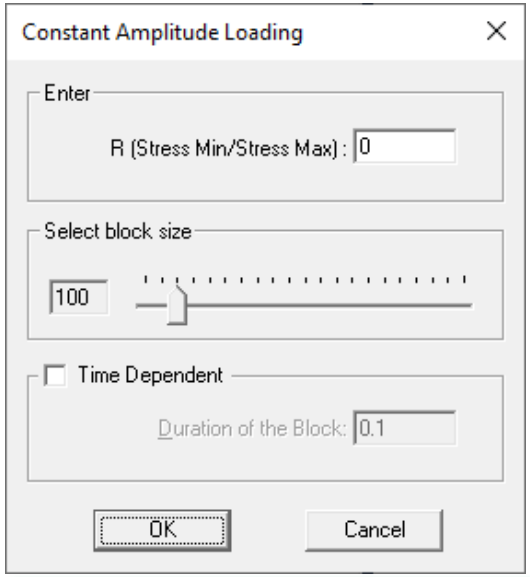


Select any material available in AFGROW using the standard AFGROW material selection



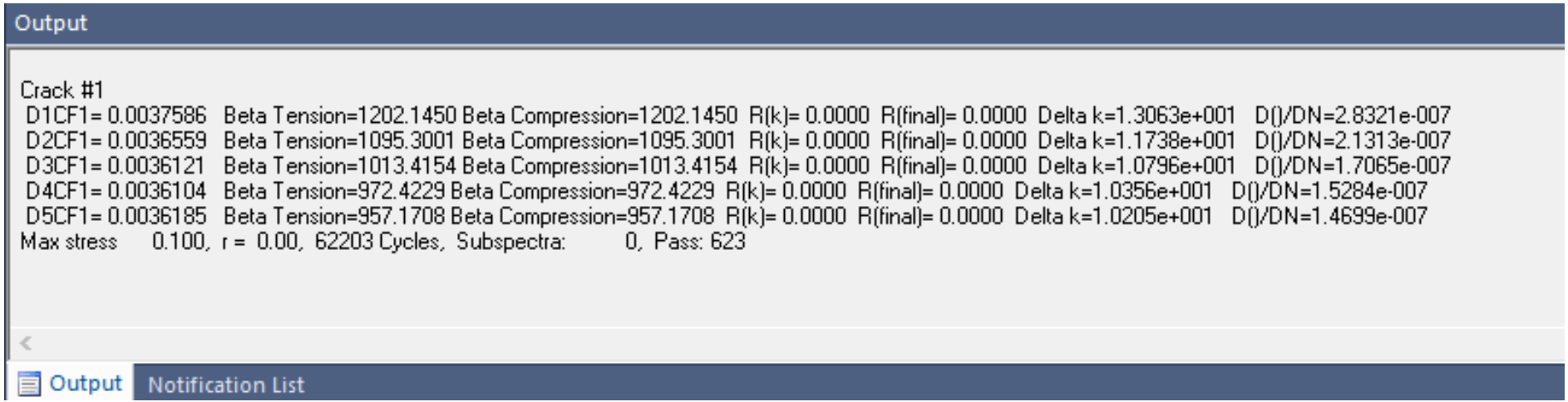
Assign a Load Spectrum





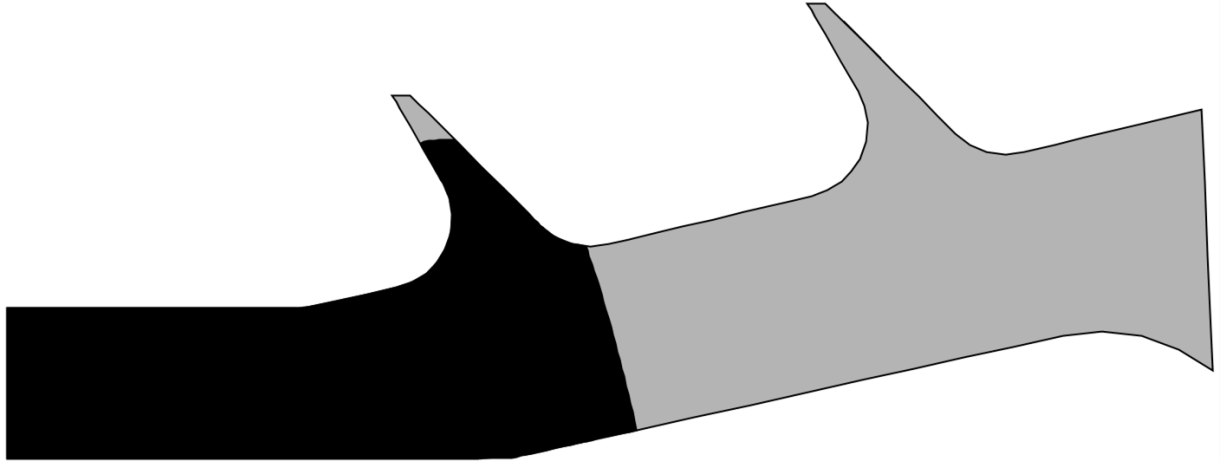
Assign a load spectrum in AFGROW using the standard AFGROW spectrum definitions

Screen Output



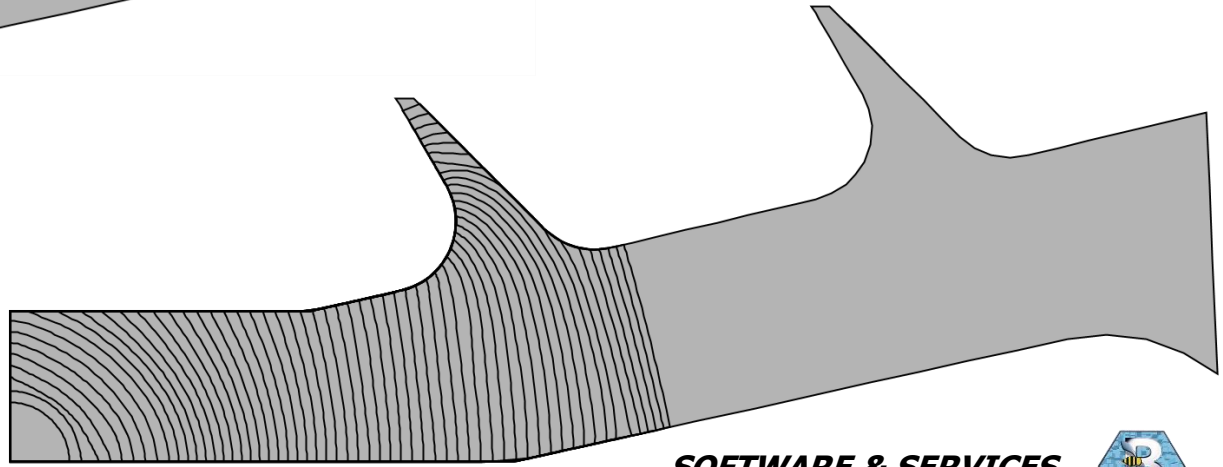
Some data for each crack front position is displayed at the bottom of the screen

Crack Plots



Crack plot during prediction

Crack plot after prediction has finished



Excel Output

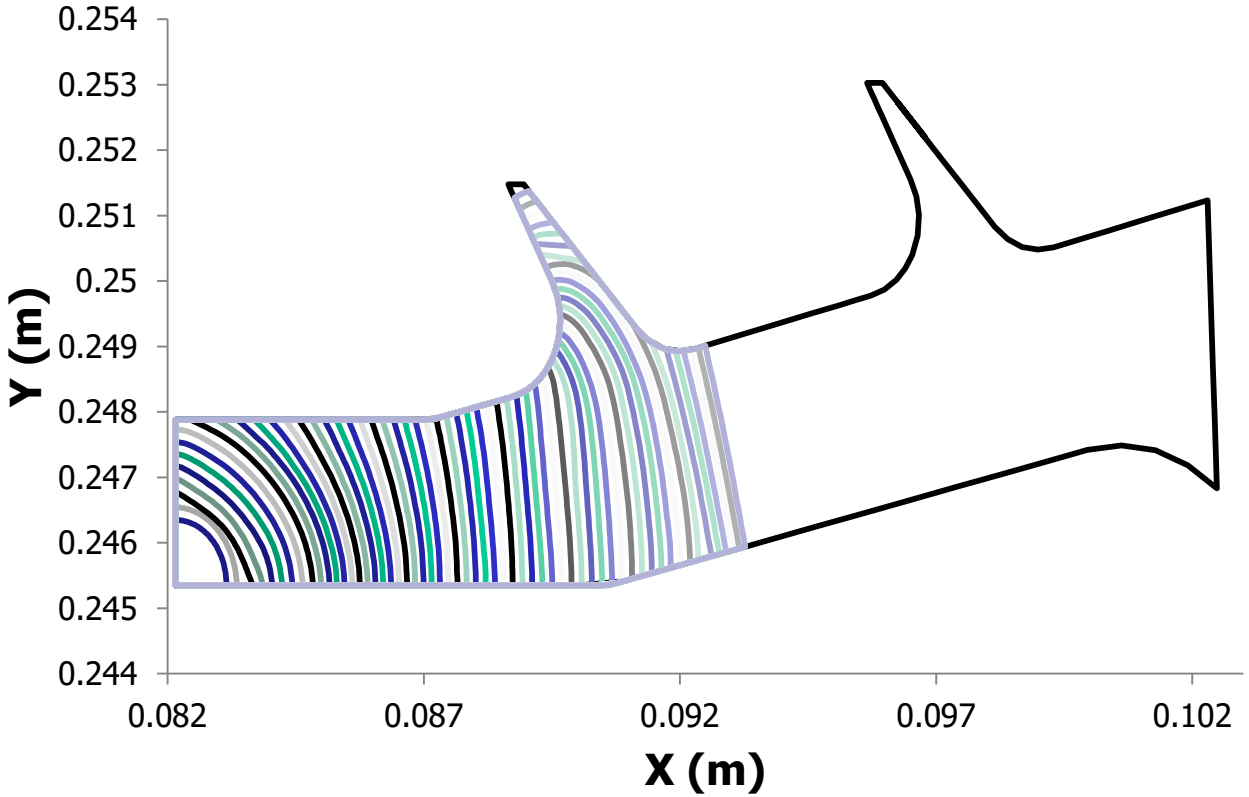
The fatigue life output is saved in the form of an excel report, this includes:

- SIF values
- Crack growth data
- Cycle counts
- Crack edge group lengths

Some graphs are also automatically plotted, including:

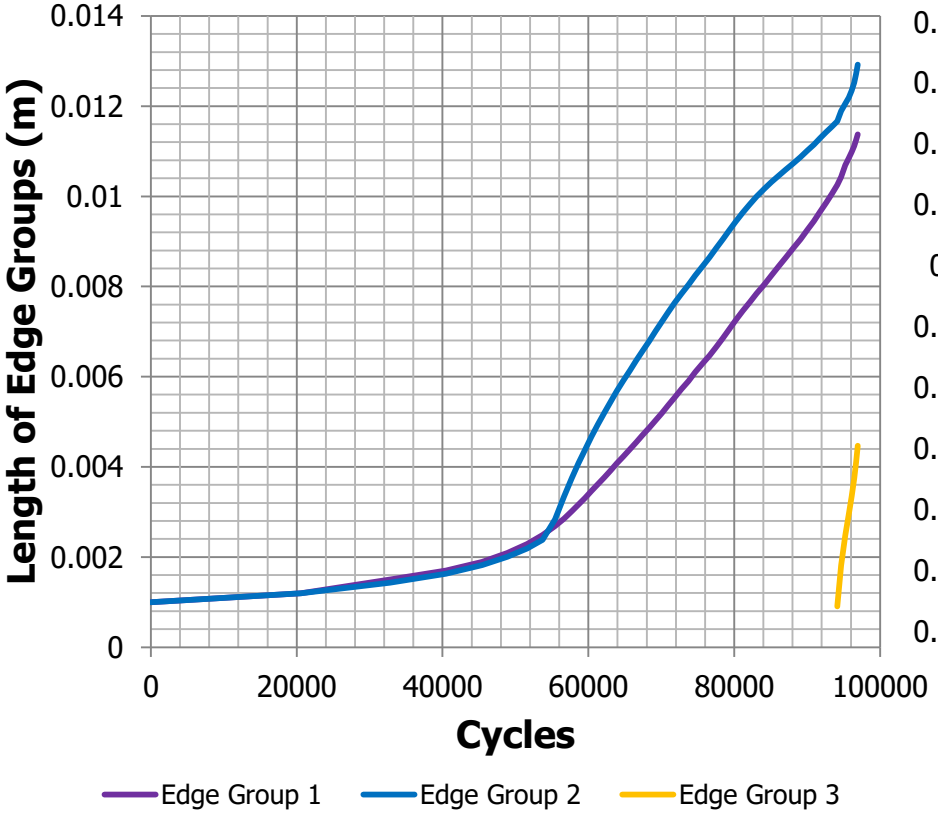
- A graph showing the cycle count at different crack increments/shapes
- A graph showing crack edge group lengths against cycles
- A graph showing the crack growth against cycles

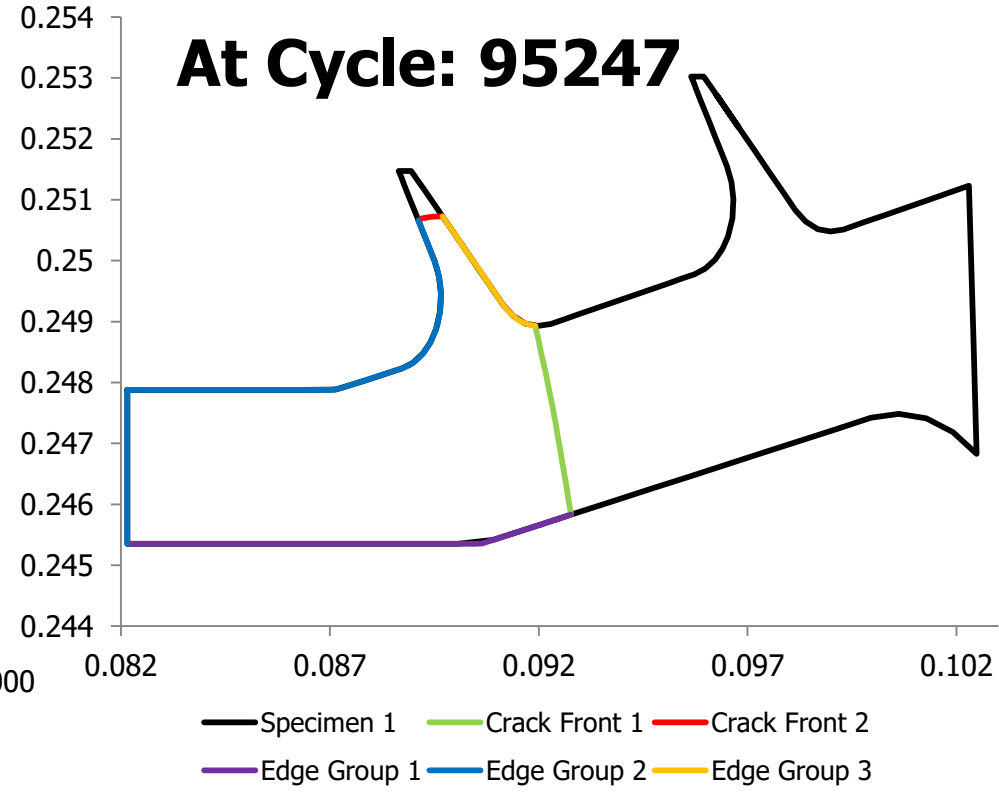
Crack Front Positions vs Cycles



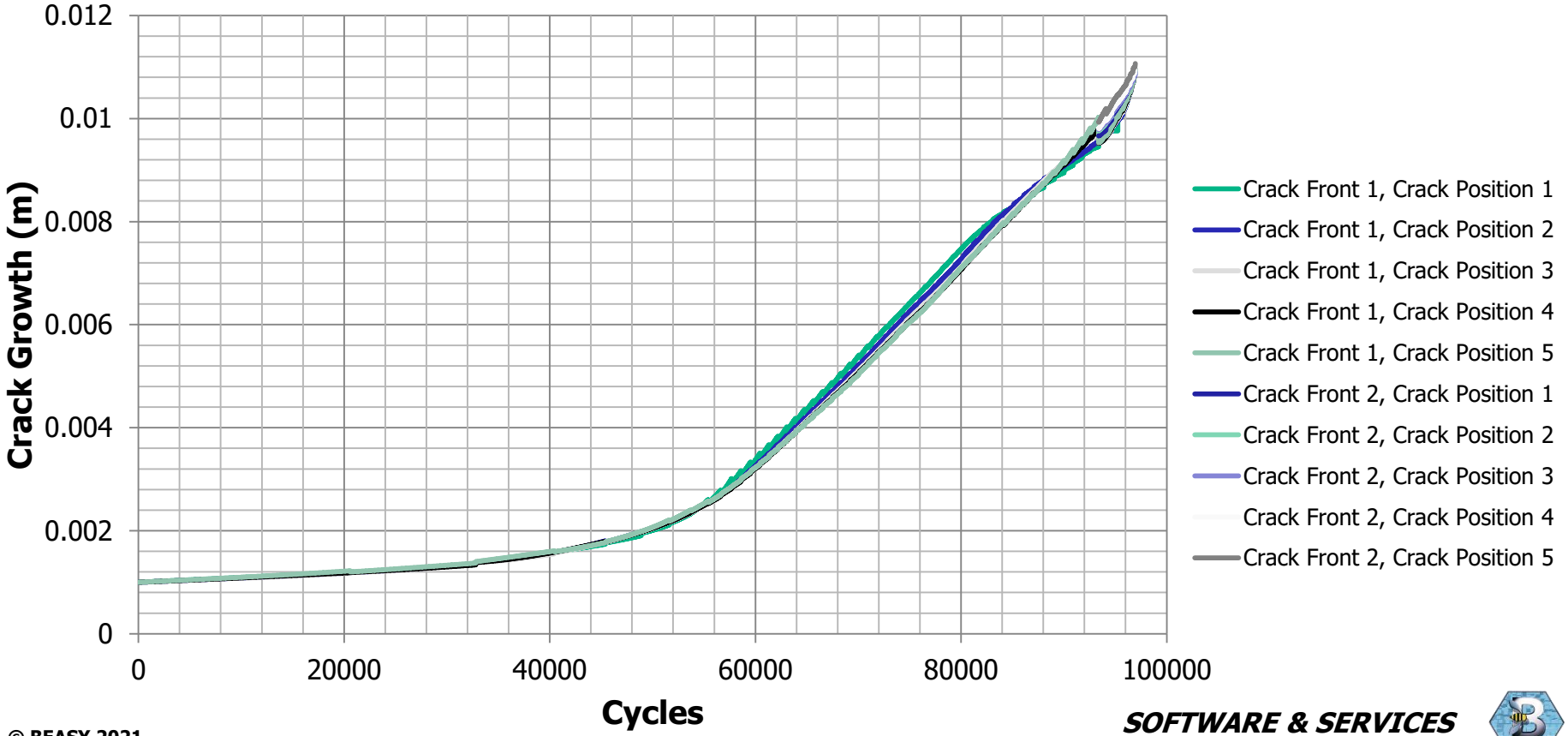
Specimen 1
Life: 0
Life: 20596
Life: 32793
Life: 40448
Life: 45411
Life: 48902
Life: 51615
Life: 53732
Life: 55405
Life: 56638
Life: 57692
Life: 58619
Life: 59544
Life: 60447
Life: 61322
Life: 62203
Life: 63065
Life: 63915
Life: 64790
Life: 65676
Life: 66570
Life: 67464
Life: 68356
Life: 69224
Life: 70095
Life: 70967
Life: 71843
Life: 72767
Life: 73706
Life: 74636
Life: 75636
Life: 76607
Life: 77547
Life: 78454
Life: 79344
Life: 80234
Life: 81187
Life: 82141
Life: 83089
Life: 84136
Life: 85108
Life: 86083
Life: 87075
Life: 88066
Life: 89069
Life: 90020
Life: 90918
Life: 91772
Life: 92592
Life: 93384
Life: 94117
Life: 94652
Life: 95247
Life: 95717
Life: 96098
Life: 96448
Life: 96729
Life: 96930
Life: 96949

Lengths Along Crack Edge Groups





Crack Growth Vs Cycles



Summary

- A new Plugin has been created which enables AFGROW users to utilise the SIF and crack path data predicted by BEASY for two and three dimensional structures
- It provides the ability to use more realistic structural models and mixed mode model crack SIF and path data

Contact Information

C M BEASY Ltd, International

Ashurst Lodge
Ashurst
Southampton
SO40 7AA

info@beasy.com

Tel: +44 238 029 3223
Fax: +44 238 029 2853
www.beasy.com

BEASY USA - Computational Mechanics International Inc

25 Bridge Street

Billerica, MA 01821

info@beasy.com

Tel: 978 667 5841

Fax: 978 667 7582

www.beasy.com