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Using the BAMF Framework to Develop a Parametric Lug AFGROW Plug-in

24 Feb 16



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Agenda



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- What is MuPMuC?
- How has it evolved?
- How can it be converted for parametric models?



What is MuPMuC BAMF?



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A
E



BAMF

INTERNATIONAL

MultiPoint MultiCrack

Broad Application for Modeling Failure

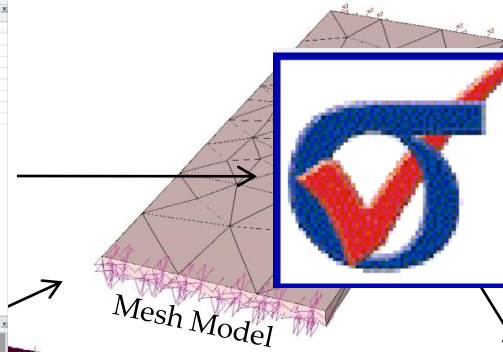


What does MuPMuC do for you?

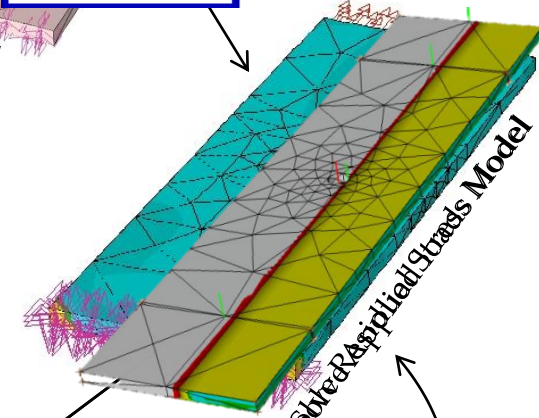


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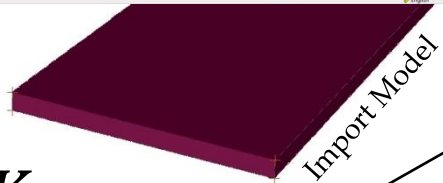
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Mesh Model



Solid Residual Stress Model

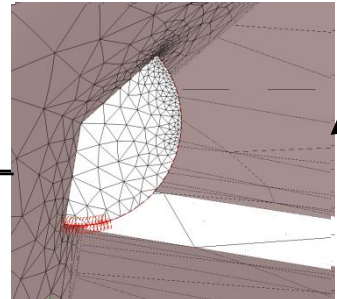


Import Model



$$K_{app\,CN} = \frac{a_{app\,CN}}{\sqrt{K_{res\,CN}}}$$

$a_{app\,CN}$
Field stress from StressCheck



Extract Stress Intensities K_{app} For each crack in the model



What does BAMF do for you?



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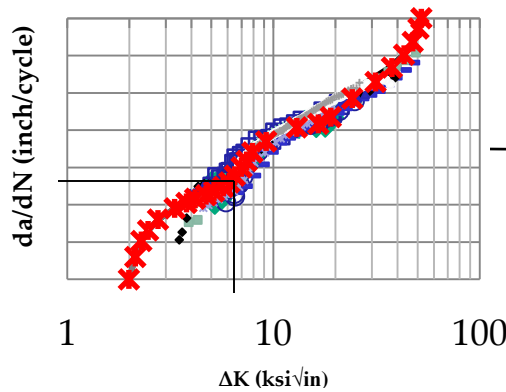
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$$K_{min_{CN}} = a_{app_{CN}} \sigma_{min} + K_{res_{CN}}$$

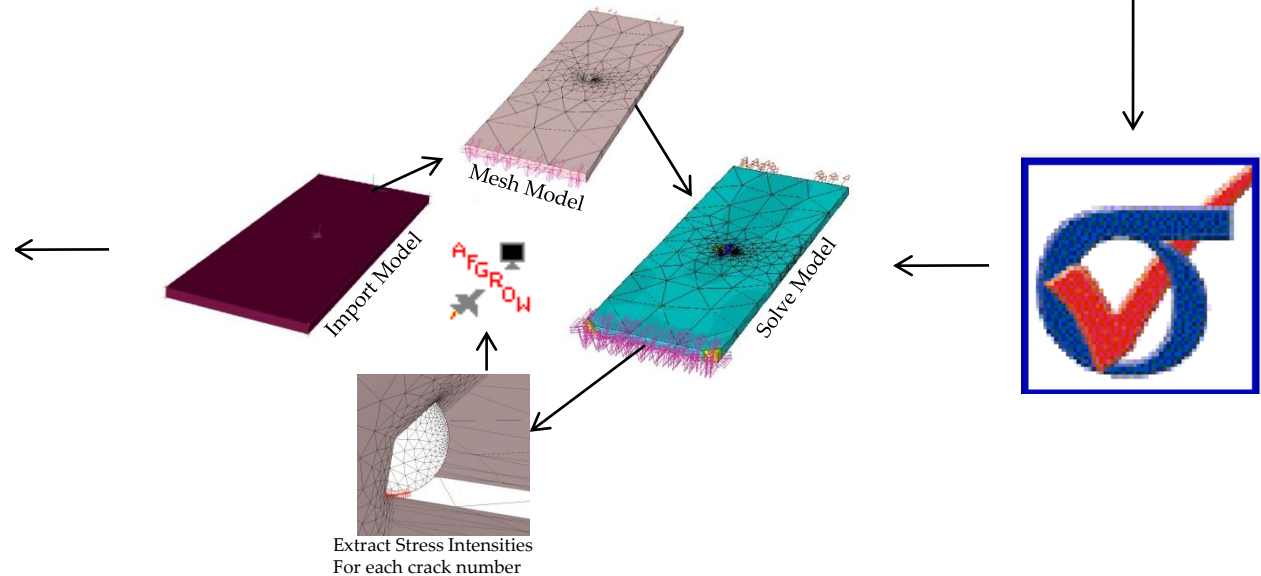
$$K_{max_{CN}} = a_{app_{CN}} \sigma_{max} + K_{res_{CN}}$$

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

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



→ New Crack Lengths



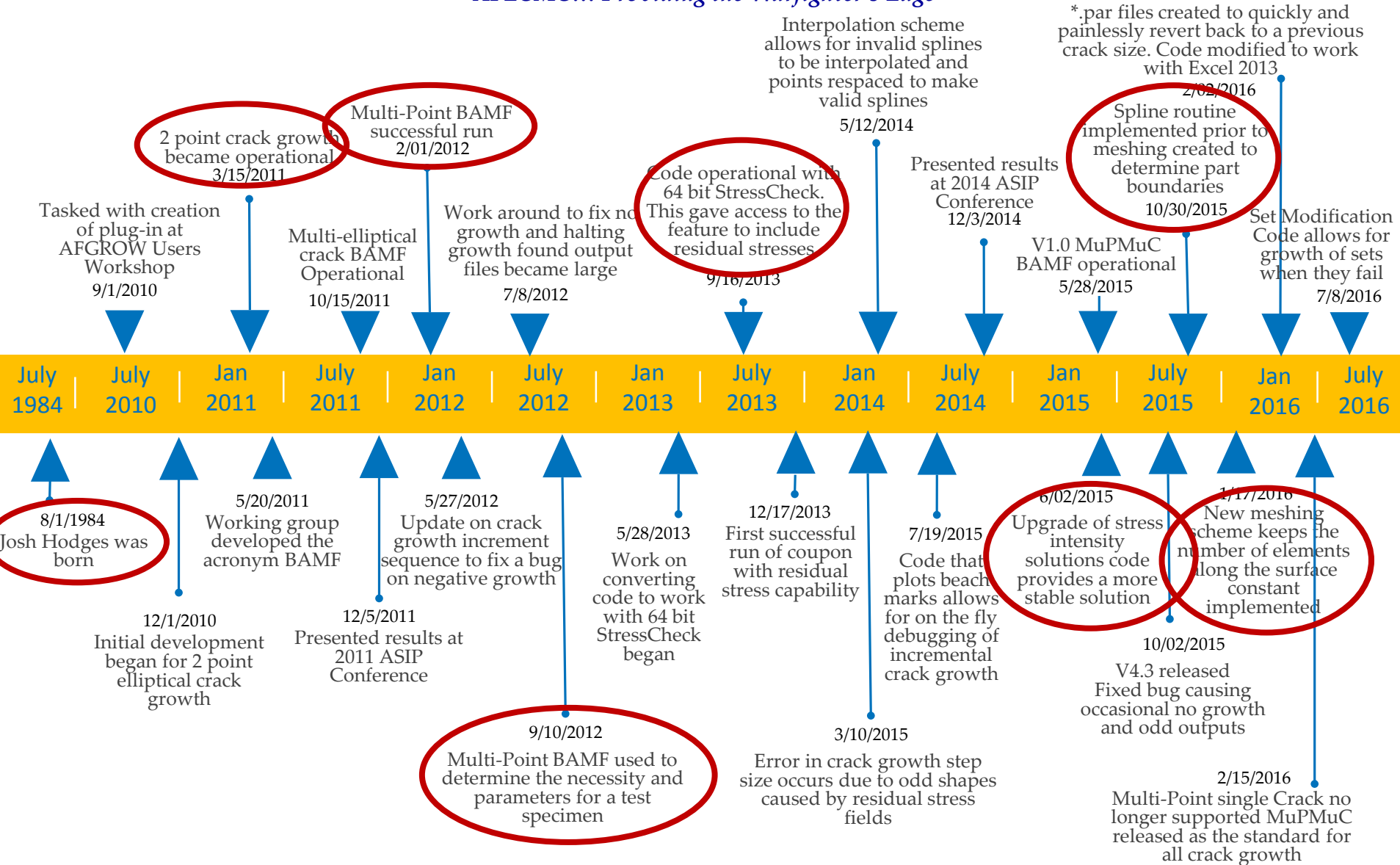


The Complete History of BAMF



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Latest Developments



- **No Growth Bug Fix**
- **Meshing Scheme**
- **K Extractions**
- **Boundary Finder**
- ***.PAR File for easy restarting of models**
- **Set Modification/Set Creation**



No Growth Bug Fix



Case Afgrow.Afgrow

teBeta

Call Ca

...

Case Afgrow.Afgrow

lengthReady

For k = 1 To N

For

d

"P" & i, "length

Nex

Next

'Crack " & k,

Predict Function Preferences

Growth Increment | Output Intervals | Output Options | Prop

Print Output Data at

- Specified Crack Growth Increment
- Specified Spectrum Cyclic Increment
- After each Spectrum Stress Level

Crack Growth: 0.0003

- Display Lifetime in Hours

Number of Hours per Pass: 1000

OK | Cancel | Save | Default

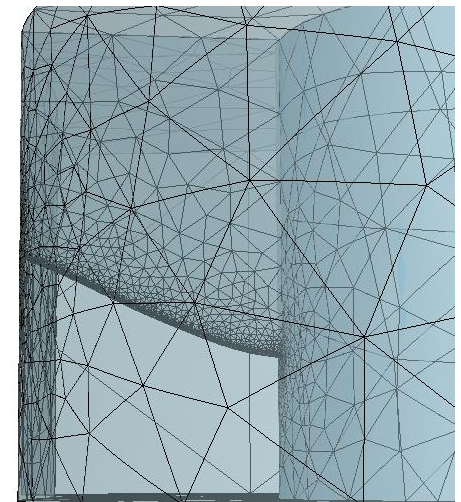
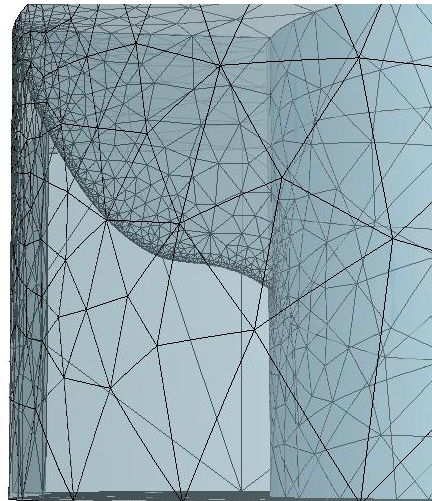
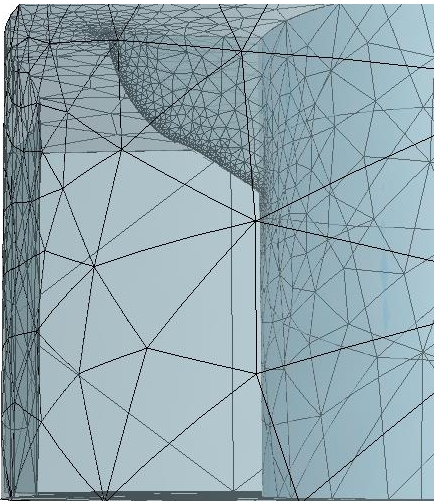
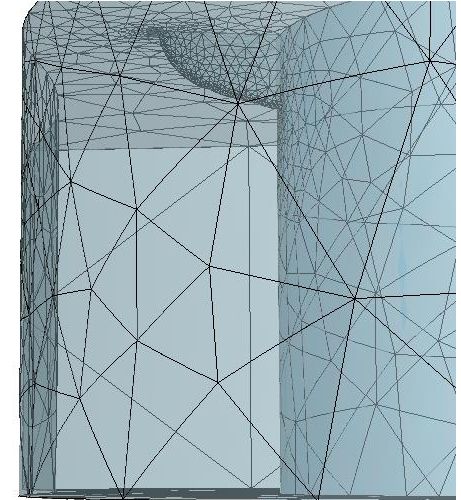
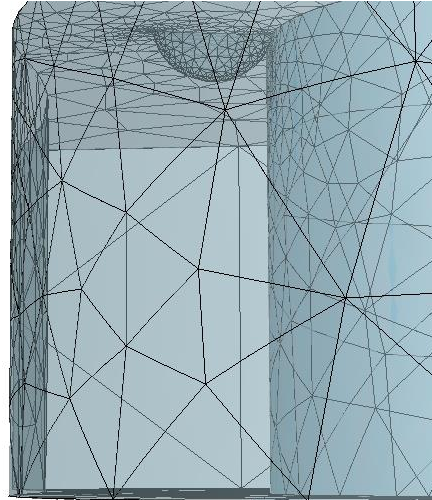
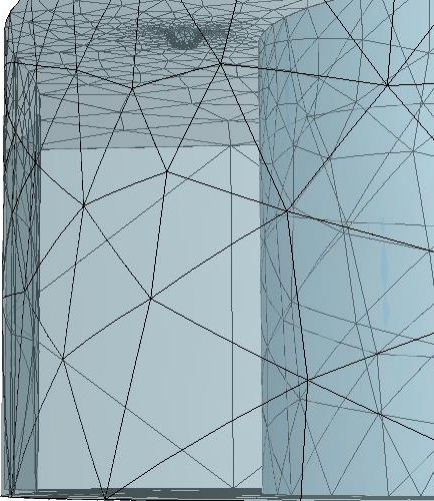


Old Meshing Scheme



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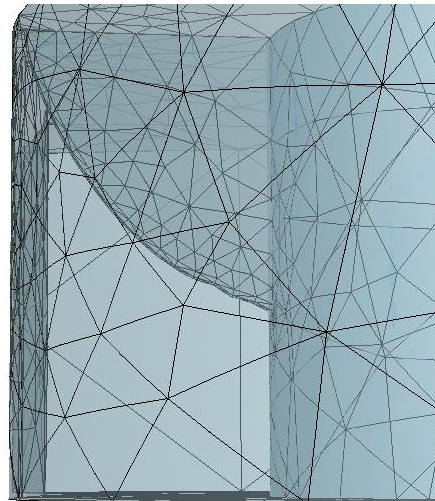
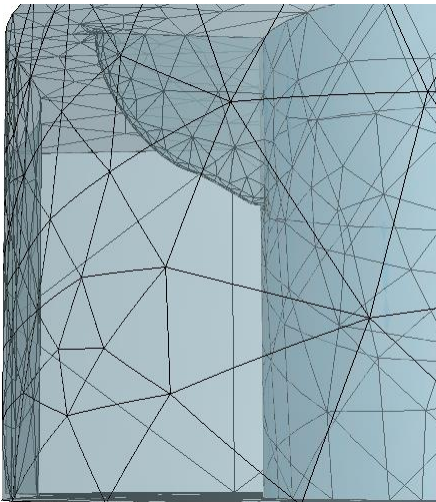
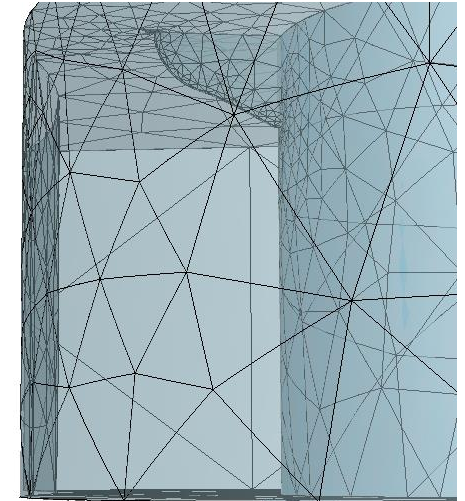
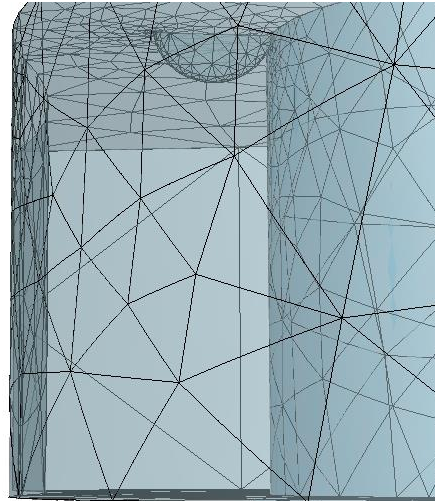
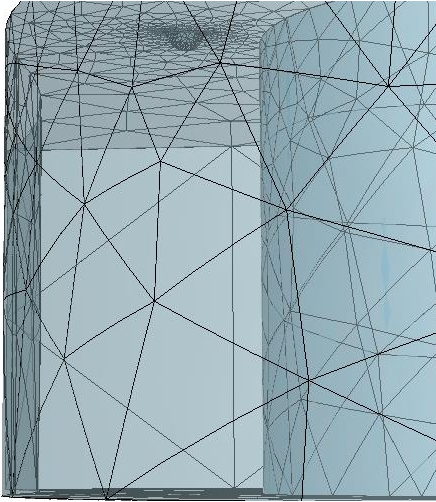


New Meshing Scheme



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New Meshing Scheme



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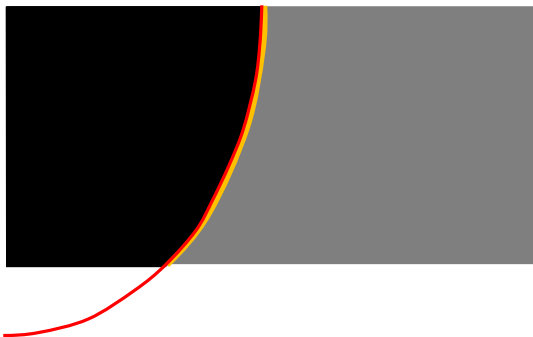
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$$\text{Boundary Layer Ratio} = \frac{\text{Total Spline Length}}{\text{Number of Elements} * \text{Body Spline Length}}$$



Total Spline Length = Body Spline Length

$$\text{BL Ratio} = \frac{1}{\text{Number of Elements}}$$



Total Spline Length \neq Body Spline Length

$$\text{BL Ratio} = \frac{\text{TSL}}{\text{BSL} * \text{Number of Elements}}$$



Old K Extraction Scheme



- **Extract 45 points**
- **Find the 3 extraction points closest to the spline point based on local angle**
- **Remove any 0 points**
- **Average the remaining points**

Problems

- **Overlap in local angle causes errors in extractions.**
- **Extraction Errors can become a major problem**



New K Extraction Scheme



- **Extract 10x Spline points**
- **Set a tolerance bound for each spline point**
- **Average the K's for anything in the tolerance bound**



Old Extraction Code



```
For i = 1 To Ipoints(CN) - 1

    AnglePoints(i) = 180 * Math.Atan2(Py(Count, CN, i), Px(Count, CN, i)) /
Math.PI

    For j = NRows - 2 To 1 Step -1 If AngleData(j) = 0 Then

        Else
            If AnglePoints(i) > AngleData(j) Then
                If j = 1 Then
                    Kp(Count, CN, i) = (SCData.Data(2, 5) + SCData.Data(3, 5))
/ 2

                    If SCData.Data(2, 5) = 0 Then
                        Kp(Count, CN, i) = SCData.Data(3, 5)
                        If SCData.Data(3, 5) = 0 Then
                            Kp(Count, CN, i) = 0
                        End If
                    End If
                End If

            Else
                If SCData.Data(j - 1, 5) = 0 Then
                    If SCData.Data(j + 1, 5) = 0 Then
                        Kp(Count, CN, i) = SCData.Data(j, 5)
                    Else
                        Kp(Count, CN, i) = (SCData.Data(j, 5) +
SCData.Data(j + 1, 5)) / 2
```



New Extraction Code



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```
For j = 0 To Ipoints(CN) * 10 - 1
  If xppp(j) >= Px(Count, CN, i) - k_tol And xppp(j) <= Px(Count, CN, i) + k_tol Then
    If yppp(j) >= Py(Count, CN, i) - k_tol And yppp(j) <= Py(Count, CN, i) + k_tol Then
      If SCData.Data(j, 5) <> 0 Then
        StoreKp = StoreKp + SCData.Data(j, 5)
        CountKp = CountKp + 1
      End If
    End If
  End If

Next j

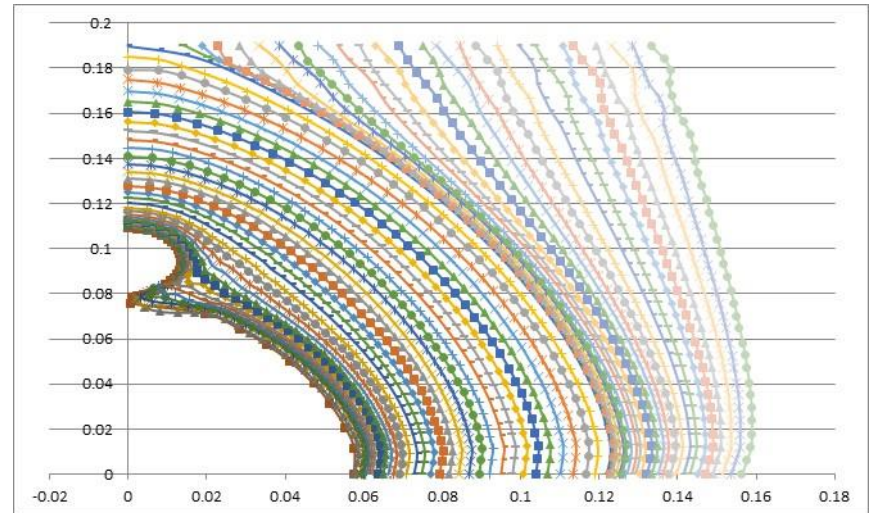
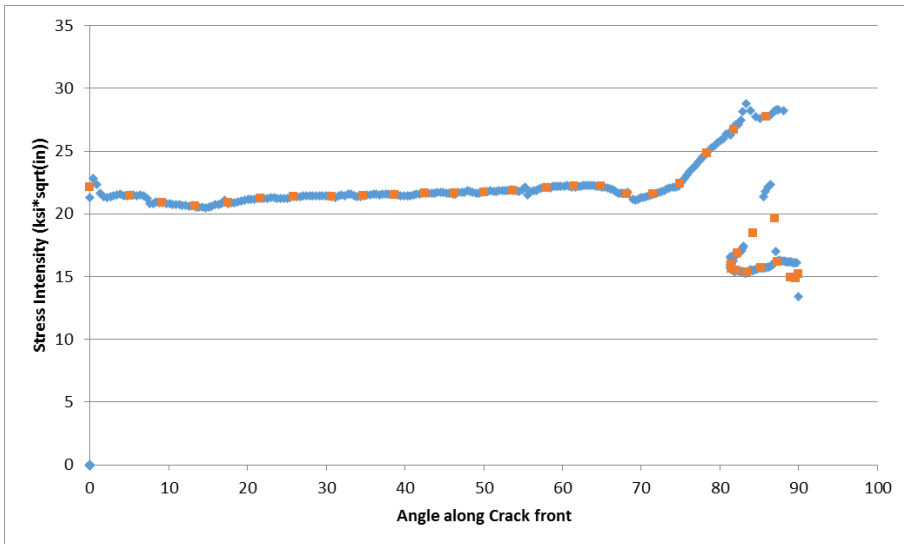
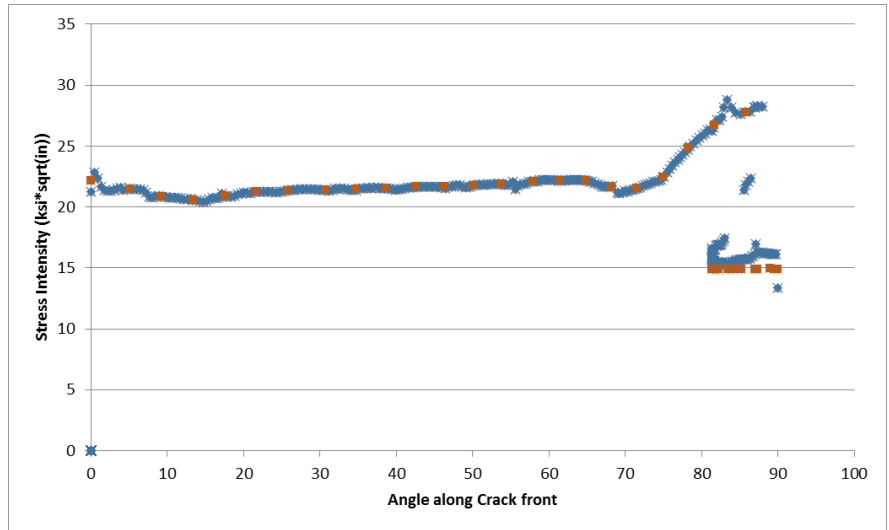
If StoreKp = 0 Then
  Kp(Count, CN, i) = 0
Else
  Kp(Count, CN, i) = StoreKp / CountKp
End If
StoreKp = 0
CountKp = 0
Next i
```



New vs Old



Old Method:
Crack would never grow properly at this point.
Stress intensities selected wouldn't let the crack grow naturally
This inevitably leads to a unstable crack and BAMF failure



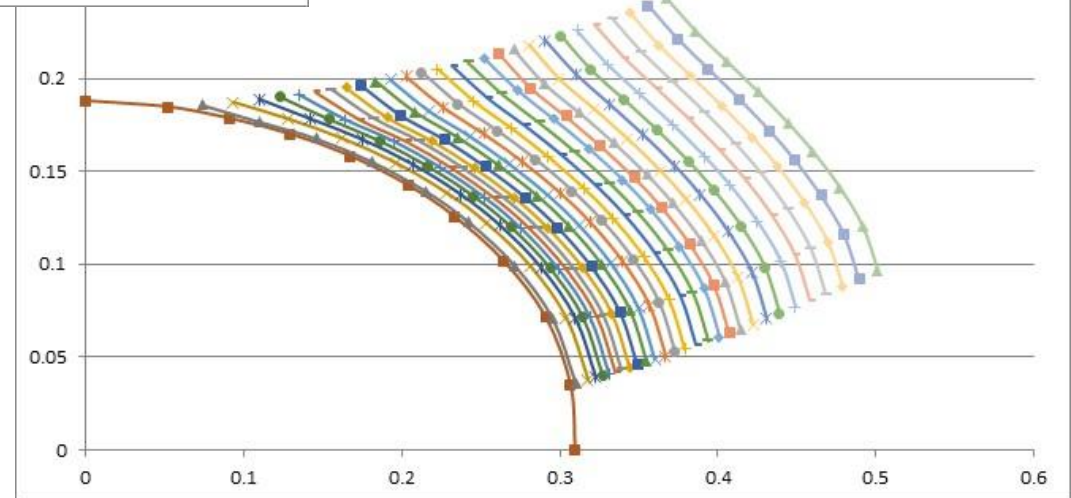
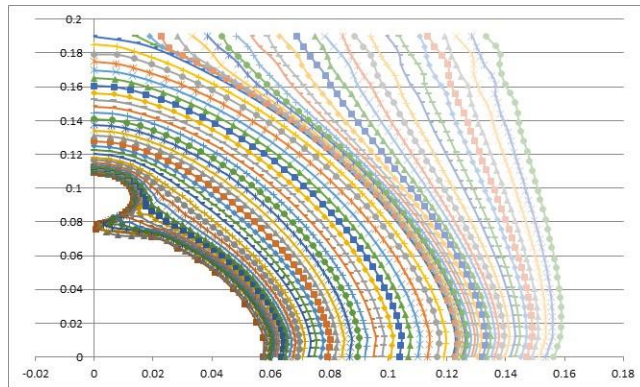
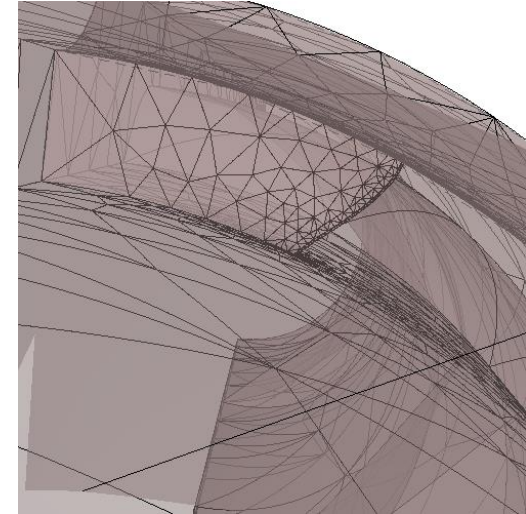
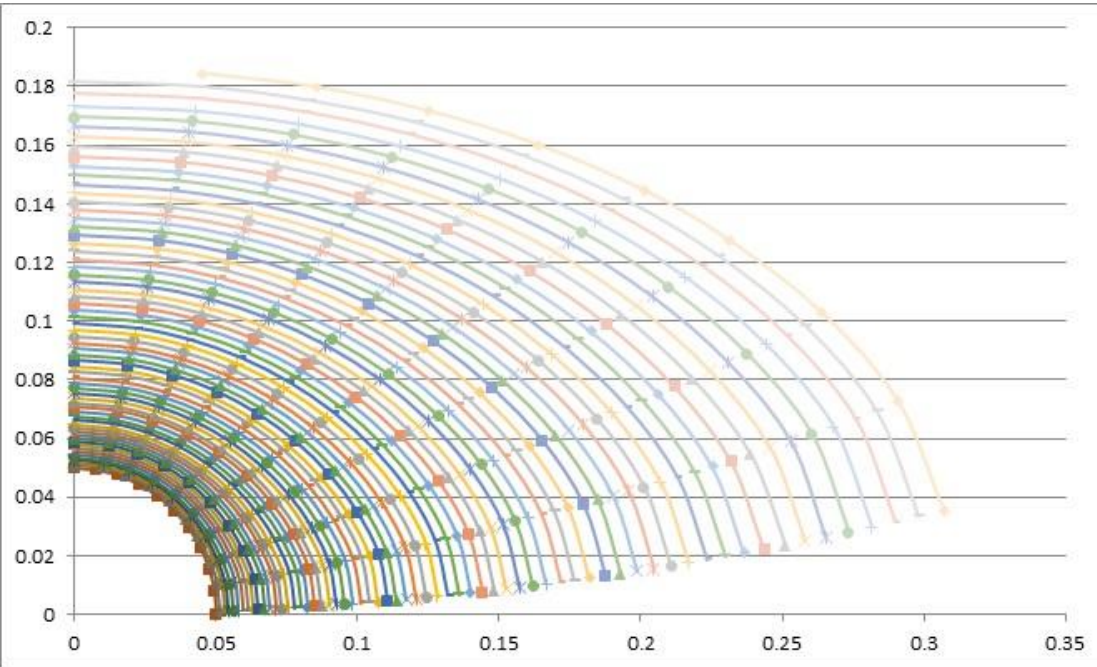


Spline Boundary Finder



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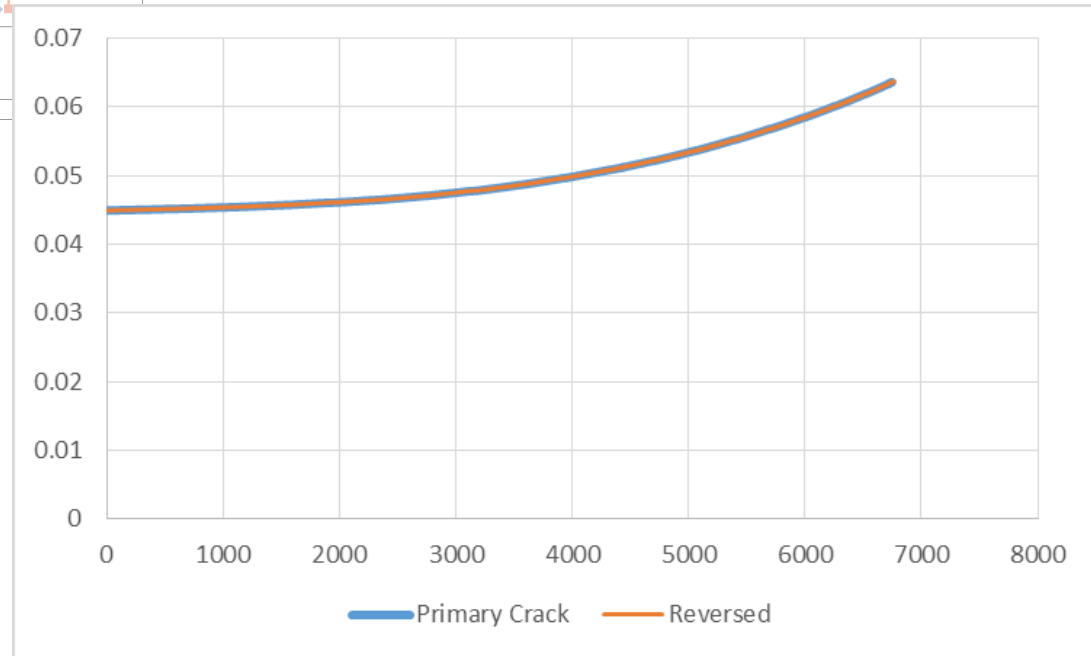
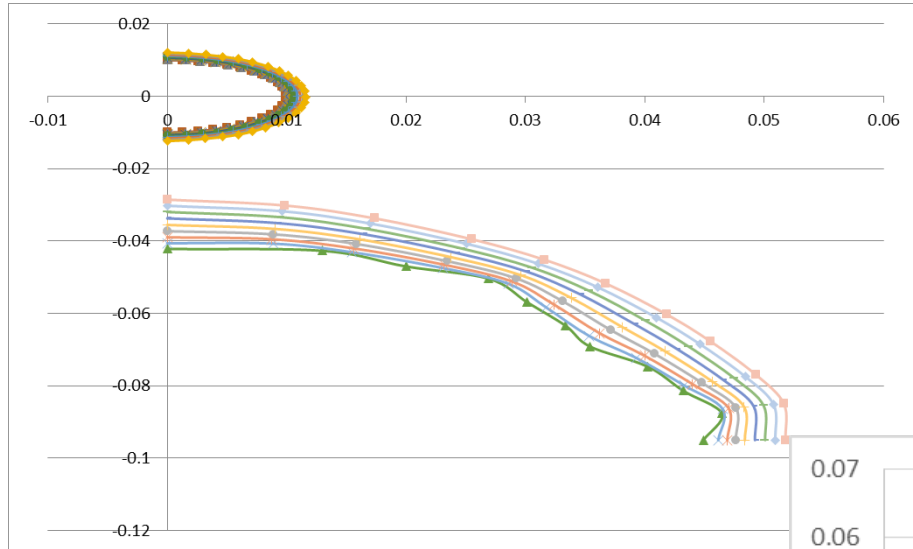


Multi-Point Multi-Crack Growth



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Modifying MuPMuC for Standard Parametric Models



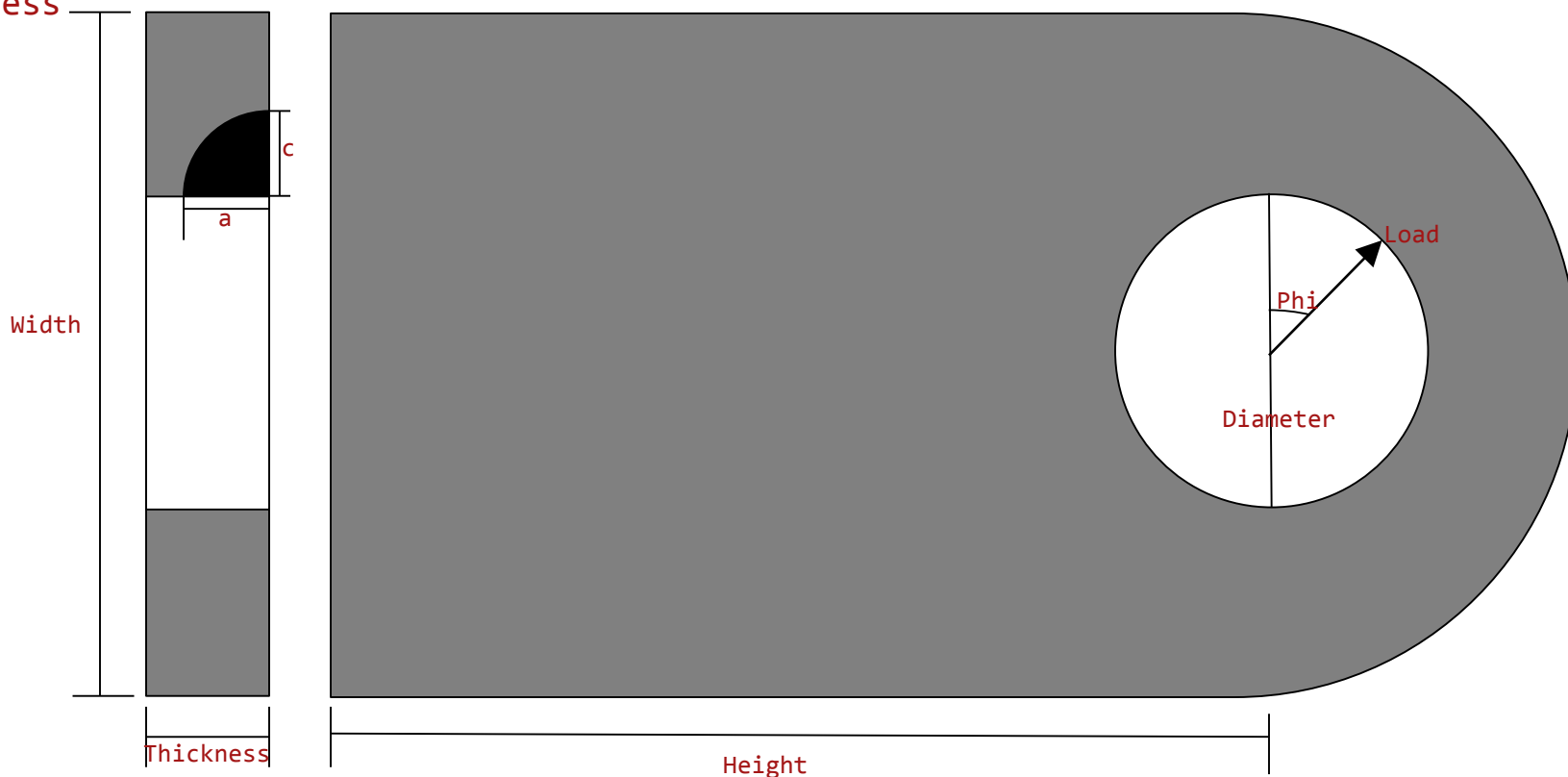
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Anywhere the statement in green appears in the following slides all the parameters below should be included

Enter Each Parameter in here like below

- Height
- Width
- Diameter
- Thickness
- Load
- Phi
- c
- a





Changing Parameters to AFGROW Plug-in



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```
Public Function GetParameterList() As Object Implements Afgrow.IDualAfgrowBetaPluginInt.GetParameterList
```

```
    Dim aParam(7) As String
```

```
        'Enter Each Parameter in here like below
```

```
        ...
```

```
        aParam(6) = "a"
```

```
        ...
```

```
    Return CObj(aParam)
```

```
    MsgBox("Get Parameter List")
```

```
End Function
```

```
Public Function GetParameterDescription(ByVal sID As String) As String Implements Afgrow.IDualAfgrowBetaPluginInt.GetParameterDes
```

```
    Select Case sID
```

```
        'Enter Each Parameter in here like below
```

```
        ...
```

```
        Case "c" : Return "c"
```

```
        ...
```

```
    End Select
```

```
End Function
```

```
Public Function GetParameterName(ByVal sID As String) As String Implements Afgrow.IDualAfgrowBetaPluginInt.GetParameterName
```

```
    Select Case sID
```

```
        'Enter Each Parameter in here like below
```

```
        ...
```

```
        Case "Height" : GetParameterName = "Height"
```

```
        ...
```

```
    End Select
```

```
End Function
```

```
Public Function GetParameterType(ByVal sID As String) As Afgrow.AfgrowPluginParameterType Implements Afgrow.IDualAfgrowBetaPluginInt
```

```
    Select Case sID
```

```
        'Enter Each Parameter in here like below
```

```
        ...
```

```
        Case "Width" : Return Afgrow.AfgrowPluginParameterType.ParamDouble
```

```
        ...
```

```
    End Select
```

```
End Function
```



Parameters in StressCheck



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StressCheck 10.2 - New Project - [New Project]

File Edit Class View Display Tools Help

3D Elasticity in/lbf/sec/F All Objects

StressCheck Model Information

Name	Description	Expression	Value	Limit	Class	Sort
C1Py3			1.1854e-002		General	
C1Py4			1.5451e-002		General	
C1Py5			1.9651e-002		General	
C1Py6			2.3032e-002		General	
C1Py7			2.6284e-002		General	
C1Py8			2.9389e-002		General	
C1Py9			3.2330e-002		General	
CrackAngle1	Sets the crack angle 1 for corner cracks 90 degrees		9.0000e+001		General	
Cracks	Defines the number of cracks in MuPMuC		1.0000e+000		General	
Dinner			7.5000e-001		General	
Em			1.0500e+007		General	
H			5.0000e+000		General	
Phi			0.0000e+000		General	
Pload			5.0000e+003		General	
PointsCrack1	Defines the number of points of Crack1		2.1000e+001		General	
Stress thickness		Pload	5.0000e+003		General	
v			1.2500e-001		General	
W			3.3000e-001		General	
			5.0000e+000		General	

Accept Delete Auto Step: 0.2

Input Settings File

StressCheck Input

Geometry Mesh Section Prop. Thickness

Select Any Object Locate

Screen:

X:

Y:

Z:

Rot-X:

Rot-Y:

Rot-Z:

Data Index

Move Replace Delete DeLast

Copy Assoc. Disassoc.

Action: Select ANY GEOM. OBJECT at screen LOCATION.

[in/lbf/sec/F] [Rotate] NUM

3:12 PM



Building the StressCheck Model Based on AFGROW Inputs



```
Public Sub CreateModel(ByVal root As String)
    Try
        ...
        Stress = dLoad

        'Assigns the material data taken from the afgrow mat file
        SCDoc.ParameterAssign("Em", Em, False)
        SCDoc.ParameterAssign("v", Poisson, False)
        SCDoc.ParameterAssign("Diameter", dDiameter, False)
        SCDoc.ParameterAssign("H", dHeight, False)
        SCDoc.ParameterAssign("Pload", dLoad, False)
        SCDoc.ParameterAssign("Phi", dPhi, False)
        SCDoc.ParameterAssign("thickness", dThickness, False)

        For i = 0 To Ipoints(1) - 1
            SCDoc.ParameterAssign(("C" & 1 & "Px" & i), Px(0, 1, i), False)
            SCDoc.ParameterAssign(("C" & 1 & "Py" & i), Py(0, 1, i), False)
        Next i

        SCDoc.ParameterAssign("W", dWidth, True)
        'Creates a
        SCDoc.Model.Export(Left(dSCML, Len(dSCML) - 4) & "start.scw")

        UpdateCrackLocations()
        UpdateParameters()

    Catch ex As Exception

    End Try
End Sub
```



Plug-in Updates/Suggestions



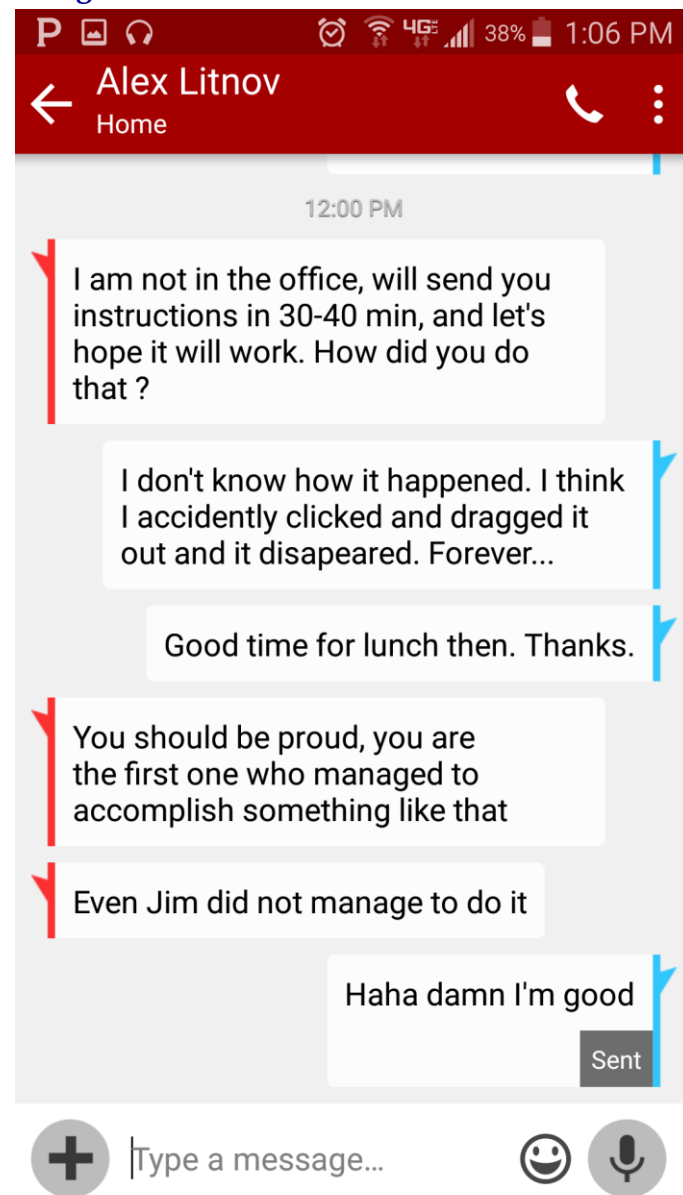
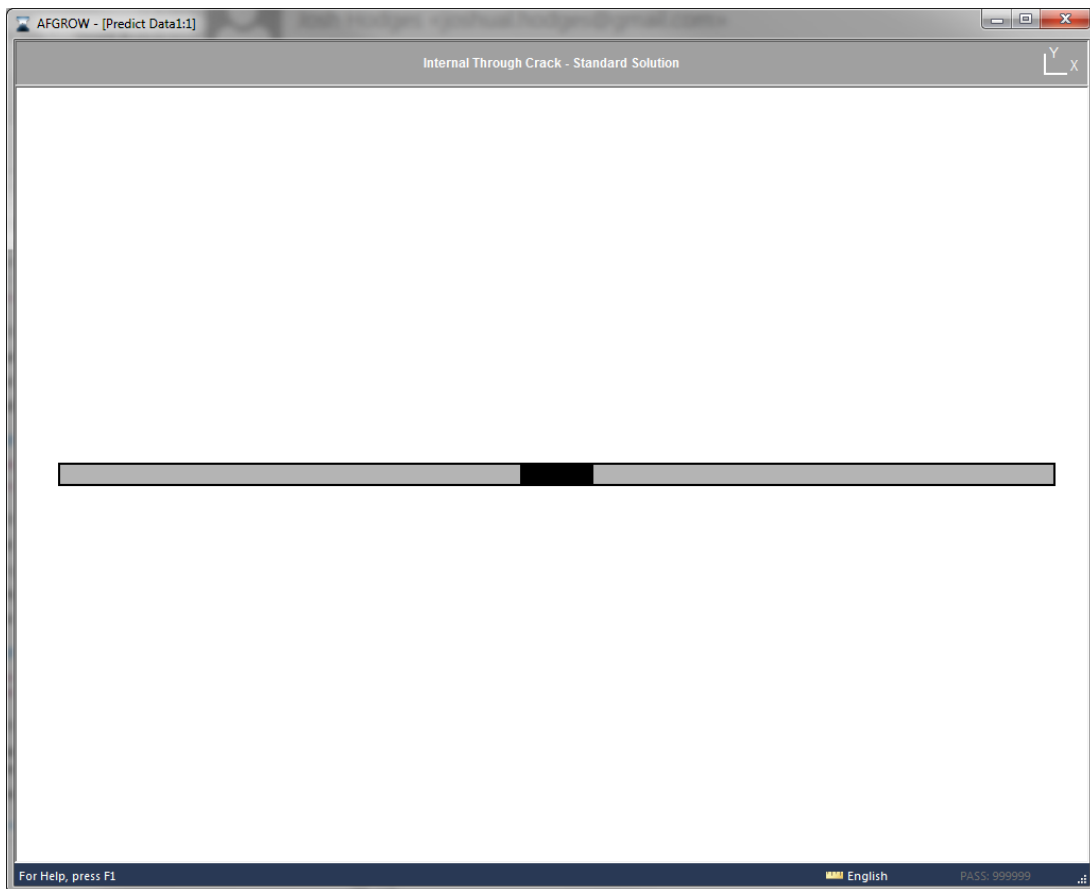
- **Writing to AFGROW output files every time the AFGROWCalculateBeta Routine is called rather than a growth increment**
 - Limits the size of output files
 - Makes it easier to compare to the BAMF .xls files
- **Have AFGROW provide cycle count to BAMF for passing to BAMF output files**
 - Negates needing to make comparisons between BAMF .xls files and .out files.



Questions?



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Spline Boundary Finder



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```
SCModel.Display.Curves = True
setobjs2 = SCDoc.Model.Sets.Set("CRACKFRONT" & CN).ObjectList
cnum = setobjs2(0)
For i = 0 To Ipoints(CN) * 5
    SCModel.Points.AddOffset(300000 + i + CN * 10000, cnum, i / (Ipoints(CN) * 5), 0)
Next
```

...

```
If Round(Px(Count + 1, CN, 0), 6) = Round(xppp(0), 6) Then FlagStart(Count + 1, CN) = 1
If Round(Px(Count + 1, CN, Ipoints(CN) - 1), 6) = Round(xppp(Ipoints(CN) * 5), 6) Then FlagEnd(Count + 1, CN) = 1
```

- When new crack lengths are passed offset=0 and 1 finds the ends of the crack front
- Crack points are resplined prior to the run starting
- All but the end points stay inside the surface
 - Increases 'set' Stability
 - More points inside crack front captures realism
- Easier post-processing of results
- Easier visualization of part geometry