A STUDY OF SHOT PEENING EFFECTS ON FRETTING FATIGUE

APPENDICES SUBMITTED BY

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APPENDIX A

PROGRAMME: FRETTING TESTS

The normal pressure was maintained at a constant value during these tests, whilst the axial load was cyclic with a stress ratio of -1 and a sinusoidal waveform of 20 Hz.

A.1 UNPEENED

Table A.1a: The normal load conditions for the fretting fatigue tests on unpeened aluminium alloy 2024 T351 in contact with aluminium alloy 2024 T351 and subjected to an axial stress amplitude of 70 MPa.

Specimen (no.)	Bridge set (no.)	Normal stress (MPa)	Normal load (kN)	1/2 normal load (kN)	Axial stress (MPa)	Axial load (kN)
106	2	10	0.203	0.102	70	11.2
105	2	20	0.406	0.203	70	11.2
56	3	40	0.813	0.406	70	11.2
59	5	60	1.219	0.610	70	11.2
109	5	80	1.626	0.813	70	11.2
104	5	100	2.032	1.016	70	11.2

Table A.1b: The normal load conditions for the fretting fatigue tests on unpeened aluminium alloy 2024 T351 in contact with aluminium alloy 2024 T351 and subjected to an axial stress amplitude of 100 MPa.

Specimen (no.)	Bridge set (no.)	Normal stress (MPa)	Normal load (kN)	1/2 normal load (kN)	Axial stress (MPa)	Axial load (kN)
8	1	10	0.203	0.102	100	16
2	1	10	0.203	0.102	100	16
11	1	20	0.406	0.203	100	16
103	4	20	0.406	0.203	100	16
16	1	40	0.813	0.406	100	16
9	1	40	0.813	0.406	100	16
10	1	60	1.219	0.610	100	16
6	1	60	1.219	0.610	100	16
18	1	80	1.626	0.813	100	16
5	1	80	1.626	0.813	100	16
19	1	100	2.032	1.016	100	16
20	1	100	2.032	1.016	100	16

Table A.1c: The normal load conditions for the fretting fatigue tests on unpeened aluminium alloy 2024 T351 in contact with aluminium alloy 2024 T351 and subjected to an axial stress amplitude of 125 MPa.

Specimen (no.)	Bridge set (no.)	Normal stress (MPa)	Normal load (kN)	1/2 normal load (kN)	Axial stress (MPa)	Axial load (kN)
39	2	10	0.203	0.102	125	20
40	1	20	0.406	0.203	125	20
38	1	40	0.813	0.406	125	20
37	1	60	1.219	0.610	125	20
100	5	80	1.626	0.813	125	20
102	3	80	1.626	0.813	125	20
101	2	100	2.032	1.016	125	20
108	3	100	2.032	1.016	125	20

A.2 PEENED

Table A.2a: The normal load conditions for the fretting fatigue tests on peened aluminium alloy 2024 T351 in contact with aluminium alloy 2024 T351 and subjected to an axial stress amplitude of 70 MPa.

Specimen (no.)	Bridge set (no.)	Normal stress (MPa)	Normal load (kN)	1/2 normal load (kN)	Axial stress (MPa)	Axial load (kN)
9P	8	10	0.203	0.102	70	11.2
2P	8	60	1.219	0.610	70	11.2
5P	7	100	2.032	1.016	70	11.2

Table A.2b: The normal load conditions for the fretting fatigue tests on peened aluminium alloy 2024 T351 in contact with aluminium alloy 2024 T351 and subjected to an axial stress amplitude of 100 MPa.

Specimen (no.)	Bridge set (no.)	Normal stress (MPa)	Normal load (kN)	1/2 normal load (kN)	Axial stress (MPa)	Axial load (kN)
6P	7	10	0.203	0.102	100	16
8P	8	60	1.219	0.610	100	16
4P	8	100	2.032	1.016	100	16

Table A.2c: The normal load conditions for the fretting fatigue tests on peened aluminium alloy 2024 T351 in contact with aluminium alloy 2024 T351 and subjected to an axial stress amplitude of 125 MPa.

Specimen (no.)	Bridge set (no.)	Normal stress (MPa)	Normal load (kN)	1/2 normal load (kN)	Axial stress (MPa)	Axial load (kN)
3P	7	10	0.203	0.102	125	20
10P	7	40	0.813	0.406	125	20
1P	7	100	2.032	1.016	125	20

APPENDIX B

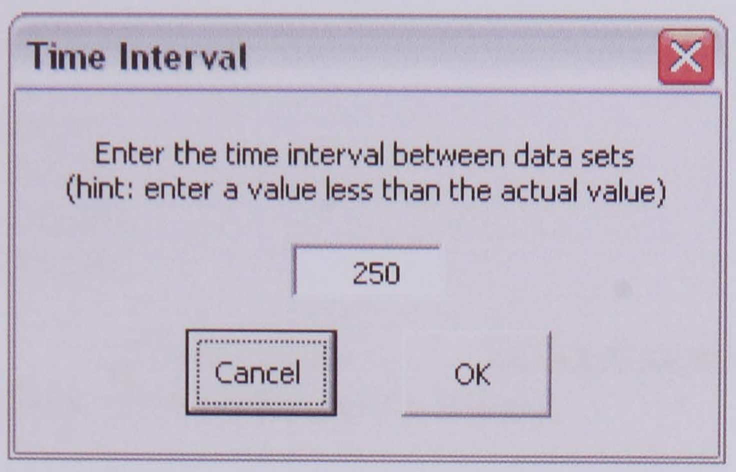
PROGRAM: CYCLIC DATA ANALYSIS

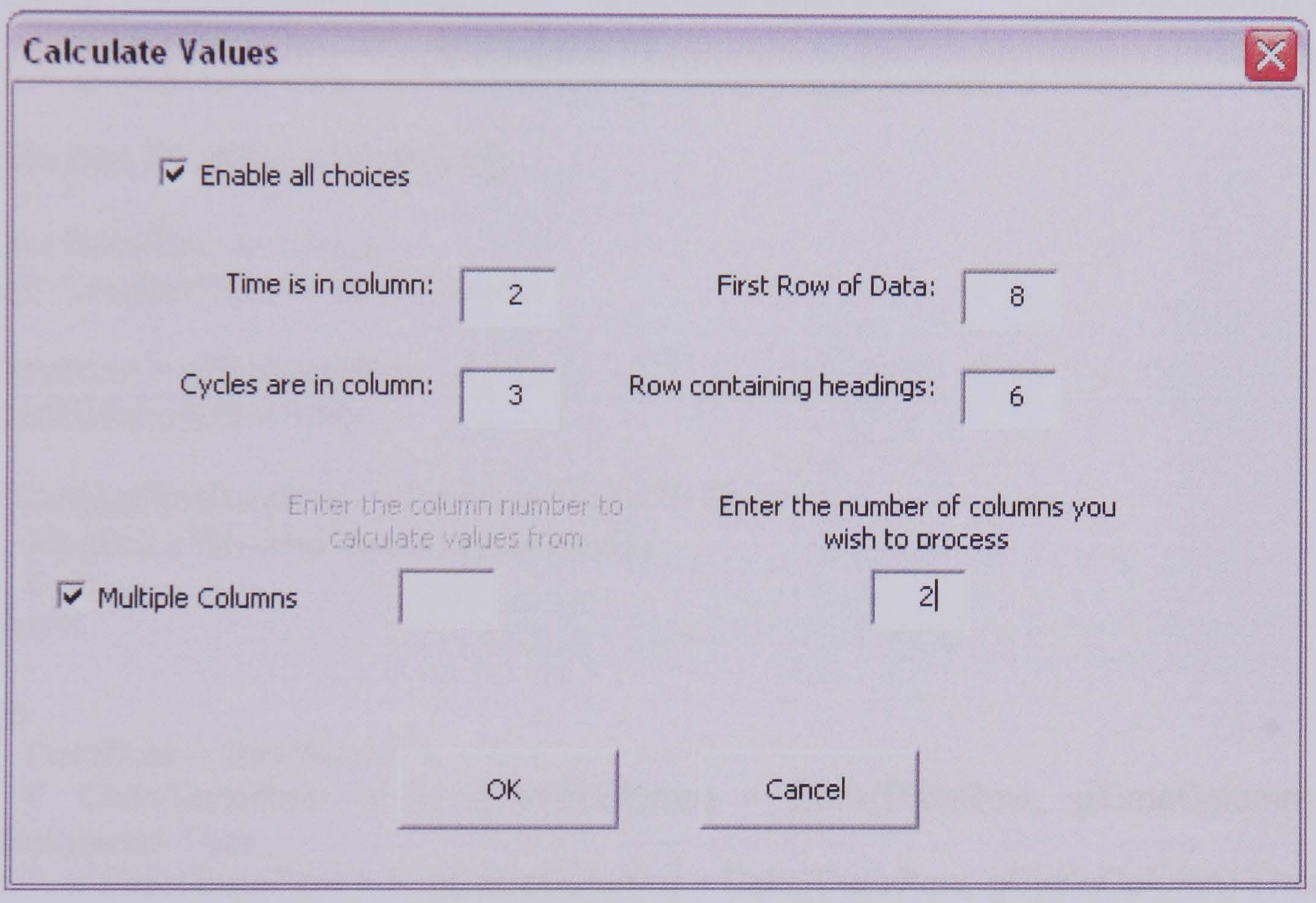
This Visual Basic program post processes data collected by the Rubicon data logging system to evaluate the maximum, minimum and average values for each fatigue cycle.

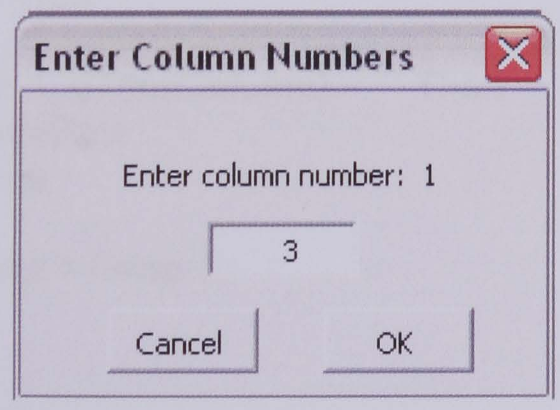
B.1 INSTRUCTIONS

Click ‘Open File’ and select all files.
Navigate to and open the required ASC file.
Choose ‘Delimited’ and select both the ‘Tab’ and ‘Space’ options.
Click ‘Finish’.
There should be no empty columns.
Click ‘Save As’ and save the file.
Click the ‘Process Calculations’ button on the toolbar (calculator image).
Follow the instructions onscreen to complete the process.

B.2 FORMS


Time Interval
Enter the time interval between data sets
(hint: enter a value less than the actual value)
250
Cancel
OK


Calculate Values
Enable all choices
Time is in column:
2
First Row of Data:
8
Cycles are in column:
3
Row containing headings:
6
Enter the column number to calculate values from
Enter the number of columns you wish to process
Multiple Columns
2
OK
Cancel


Enter Column Numbers
Enter column number: 1
3
Cancel
OK

B.3 VISUAL BASIC CODE

```
Option Explicit

Dim  gDataSets() As Integer
Dim  gAverages() As Double
Dim  gMaximums() As Double
Dim  gMinimums() As Double

Dim  gFinalDataRow,        gTimeColumn,        gCycleColumn,        gTimeInterval,
      gNumberOfDataSets, gFirstDataRow As Integer

Global  gColumnNumberList() As Integer
Global  gFormTimeIntervalFlag,        gFormCalculateFlag,        gMultiColumnFlag,
        gFormGetColumnsFlag As Boolean
Global  gColumnNumber, gHeadingRow, gColumnLoopNumber As Integer
```

Public Sub FindFinalDataPoint()

```
   Dim DataRow As Integer
   Dim LastDataFound As Boolean

   DataRow = gFirstDataRow - 1
   LastDataFound = False

   If Cells(gFirstDataRow, gTimeColumn) = "" Then
      MsgBox ("No data found in first row")
      End
   End If

   Do
      DataRow = DataRow + 1
      If  Cells(DataRow  +  1,  gTimeColumn)  -  Cells(DataRow,  gTimeColumn)  >
gTimeInterval Then
         If Cells(DataRow + 1, gCycleColumn) = Cells(DataRow, gCycleColumn) Then
            gFinalDataRow = DataRow
            LastDataFound = True
         End If
      ElseIf Cells(DataRow + 1, gTimeColumn) = "" Then
         gFinalDataRow = DataRow
         LastDataFound = True
      End If
   Loop While LastDataFound = False

End Sub
```

Public Sub AverageCalculations()

```
   ReDim gAverages(gNumberOfDataSets) As Double
   Dim DataRow, DataRowStart, DataRowEnd, DataSet As Integer
   Dim Sum As Double

   For DataSet = 1 To gNumberOfDataSets
      DataRowStart = gDataSets((DataSet * 2) - 1)
      DataRowEnd = gDataSets(DataSet * 2)
      Sum = 0
      For DataRow = DataRowStart To DataRowEnd
         Sum = Sum + Cells(DataRow, gColumnNumber)
      Next
      gAverages(DataSet) = Sum / (DataRowEnd - DataRowStart + 1)
   Next

End Sub
```

Public Sub FindDataSets()

```
   ReDim gDataSets(1 To 2) As Integer
   Dim DataRow, DataRowStart As Integer

   DataRow = gFirstDataRow - 1
   DataRowStart = DataRow + 1
   gNumberOfDataSets = 1

   Do
      DataRow = DataRow + 1
      If Cells(DataRow + 1, gTimeColumn) - Cells(DataRow, gTimeColumn) >
gTimeInterval Then
         gDataSets((gNumberOfDataSets * 2) - 1) = DataRowStart
         gDataSets(gNumberOfDataSets * 2) = DataRow
         If DataRow <> gFinalDataRow Then
            gNumberOfDataSets = gNumberOfDataSets + 1
            ReDim Preserve gDataSets(1 To (gNumberOfDataSets * 2)) As Integer
            DataRowStart = DataRow + 1
         End If
      ElseIf Cells(DataRow + 1, gTimeColumn) = "" Then
         gDataSets((gNumberOfDataSets * 2) - 1) = DataRowStart
         gDataSets(gNumberOfDataSets * 2) = DataRow
      End If
   Loop While DataRow <> gFinalDataRow

   If Cells(gDataSets((gNumberOfDataSets * 2) - 1), gCycleColumn) =
Cells(gDataSets(gNumberOfDataSets * 2), gCycleColumn) Then
      gNumberOfDataSets = gNumberOfDataSets - 1
   End If

   If gNumberOfDataSets = 0 Then
      MsgBox ("No valid data sets exist")
      End
   End If

End Sub
```

Public Sub MaximumCalculations()

```
ReDim gMaximums(gNumberOfDataSets) As Double
Dim DataRow, DataRowStart, DataRowEnd, DataSet As Integer
Dim MaximumValue As Double

For DataSet = 1 To gNumberOfDataSets
   DataRowStart = gDataSets((DataSet * 2) - 1)
   DataRowEnd = gDataSets(DataSet * 2)
   MaximumValue = Cells(DataRowStart, gColumnNumber)
   For DataRow = DataRowStart To DataRowEnd
      If Cells(DataRow, gColumnNumber) > MaximumValue Then
         MaximumValue = Cells(DataRow, gColumnNumber)
      End If
   Next
   gMaximums(DataSet) = MaximumValue
Next
```

End Sub

Public Sub MinimumCalculations()

```
ReDim gMinimums(gNumberOfDataSets) As Double
Dim DataRow, DataRowStart, DataRowEnd, DataSet As Integer
Dim MinimumValue As Double

For DataSet = 1 To gNumberOfDataSets
   DataRowStart = gDataSets((DataSet * 2) - 1)
   DataRowEnd = gDataSets(DataSet * 2)
   MinimumValue = Cells(DataRowStart, gColumnNumber)
   For DataRow = DataRowStart To DataRowEnd
      If Cells(DataRow, gColumnNumber) < MinimumValue Then
         MinimumValue = Cells(DataRow, gColumnNumber)
      End If
   Next
   gMinimums(DataSet) = MinimumValue
Next
```

End Sub

Public Sub ProcessCalculations()

```
    If ActiveWorkbook.Name = "MaxMinAvg.xls" Then
        MsgBox ("Sorry, Calculations not valid on this workbook.")
        Exit Sub
    End If
    If ActiveSheet.Name = "Calculations Sheet" Then
        MsgBox ("Sorry, calculations not valid on this sheet. Select correct sheet and try again.")
        Sheets(2).Select
        Exit Sub
    End If
    frmTimeInterval.Show
    If gFormTimeIntervalFlag = True Then
        MsgBox ("Operation Cancelled")
        End
    End If
    frmCalculate.Show
    If gFormCalculateFlag = True Then
        MsgBox ("Operation Cancelled")
        End
    End If
    gTimeColumn = Int(frmCalculate.txtTimeColumn.Text)
    gCycleColumn = Int(frmCalculate.txtCycleColumn.Text)
    gTimeInterval = Int(frmTimeInterval.txtTimeInterval.Text)
    gFirstDataRow = Int(frmCalculate.txtFirstDataRow.Text)
    gHeadingRow = Int(frmCalculate.txtHeadingRow.Text)
    If gMultiColumnFlag = True Then
        ReDim gColumnNumberList(Int(frmCalculate.txtNumberOfColumns.Text))
        For gColumnLoopNumber = 1 To Int(frmCalculate.txtNumberOfColumns.Text)
            frmGetColumns.Show
            If gFormGetColumnsFlag = True Then
                MsgBox ("Operation Cancelled")
                End
            End If
        Next
        For gColumnLoopNumber = 1 To Int(frmCalculate.txtNumberOfColumns.Text)
            gColumnNumber = gColumnNumberList(gColumnLoopNumber)
            frmPleaseWait.Show
        Next
    End If
    If gMultiColumnFlag = False Then
        gColumnLoopNumber = 1
        gColumnNumber = Int(frmCalculate.txtColumnNumber.Text)
        frmPleaseWait.Show
    End If
End Sub
```

Public Sub WriteData()

```
    Dim DataSet, CalculationCount, FirstColumn As Integer
    Dim NewSheetFlag As Boolean

    NewSheetFlag = False

    If Worksheets.count = 1 Then
        Sheets.Add
        ActiveSheet.Name = "Calculations Sheet"
        Columns(1).Hidden = True
        NewSheetFlag = True
        Cells(1, 1) = 0
    End If
    If NewSheetFlag = False Then
        Sheets("Calculations Sheet").Select
    End If

    CalculationCount = Cells(1, 1)
    FirstColumn = (CalculationCount * 9) + 2

    Range(Cells(1, FirstColumn), Cells(1, FirstColumn + 7)).Select
    With Selection
        .HorizontalAlignment = xlCenter
        .VerticalAlignment = xlBottom
        .WrapText = False
        .Orientation = 0
        .AddIndent = False
        .ShrinkToFit = False
        .MergeCells = False
    End With
    Selection.Merge
    Cells(1, FirstColumn) = "Calculations for column number" + Str(gColumnNumber) +
". Title: " + Worksheets(2).Cells(gHeadingRow, gColumnNumber)

    Range(Cells(3, FirstColumn), Cells(4, FirstColumn + 7)).Select
    Selection.HorizontalAlignment = xlCenter
    Cells(3, FirstColumn) = "Data"
    Cells(4, FirstColumn) = "Set"
    Cells(3, FirstColumn + 1) = "Time"
    Cells(4, FirstColumn + 1) = "Start"
    Cells(3, FirstColumn + 2) = "Time"
    Cells(4, FirstColumn + 2) = "End"
    Cells(3, FirstColumn + 3) = "Cycle"
    Cells(4, FirstColumn + 3) = "Start"
    Cells(3, FirstColumn + 4) = "Cycle"
    Cells(4, FirstColumn + 4) = "End"
    Cells(3, FirstColumn + 5) = "Average"
    Cells(4, FirstColumn + 5) = "Value"
    Cells(3, FirstColumn + 6) = "Maximum"
    Cells(4, FirstColumn + 6) = "Value"
    Cells(3, FirstColumn + 7) = "Minimum"
    Cells(4, FirstColumn + 7) = "Value"
```

```
    For DataSet = 1 To gNumberOfDataSets
        Cells(DataSet + 4, FirstColumn) = DataSet
        Cells(DataSet + 4, FirstColumn + 1) = Worksheets(2).Cells(gDataSets((DataSet *
2) - 1), gTimeColumn)
        Cells(DataSet + 4, FirstColumn + 2) = Worksheets(2).Cells(gDataSets((DataSet *
2)), gTimeColumn)
        Cells(DataSet + 4, FirstColumn + 3) = Worksheets(2).Cells(gDataSets((DataSet *
2) - 1), gCycleColumn)
        Cells(DataSet + 4, FirstColumn + 4) = Worksheets(2).Cells(gDataSets((DataSet *
2)), gCycleColumn)
        Cells(DataSet + 4, FirstColumn + 5) = gAverages(DataSet)
        Cells(DataSet + 4, FirstColumn + 6) = gMaximums(DataSet)
        Cells(DataSet + 4, FirstColumn + 7) = gMinimums(DataSet)
    Next
    Cells(2, FirstColumn).Select
    Cells(1, 1) = CalculationCount + 1

End Sub
```

APPENDIX C

PROGRAMME: EVOLUTION OF FRETTING SCARS

Interrupted fretting fatigue tests were conducted at three normal pressures, 10 MPa, 40 MPa or 60 MPa, and 100 MPa, these being the minimum previously applied, the maximum previously applied and that which yielded the shortest life for each axial stress in the fretting fatigue test programme. Fretting scars at a tenth, quarter, half and three quarters of the total fretting fatigue lives found previously were produced.

C.1 UNPEENED

Table C.1a: The normal load conditions and cycles administered for the scar development tests on unpeened aluminium alloy 2024 T351 in contact with aluminium alloy 2024 T351 and subjected to an axial stress amplitude of 70 MPa.

Specimen (no.)	Bridges Top (no.)	Bridges Bottom (no.)	Normal stress (MPa)	1/2 normal load (kN)	Axial stress (MPa)	Life expectancy (no.)	Life proportion (no.)	Cycles administered (no.)	Timing expected (hr)
43	R1	R2	10	0.102	70	3,733,888	1/10	373,389	5.19
49	J3	J4	10	0.102	70	3,733,888	1/4	933,472	12.96
51	R3	R4	10	0.102	70	3,733,888	1/2	1,866,944	25.93
66	G1	G2	10	0.102	70	3,733,888	3/4	2,800,416	38.89
69	H1	H2	60	0.610	70	886,320	1/10	88,632	1.23
68	O1	O2	60	0.610	70	886,320	1/4	221,580	3.08
53	K1	K2	60	0.610	70	886,320	1/2	443,160	6.16
63	P1	P2	60	0.610	70	886,320	3/4	664,740	9.23
64	L3	L4	100	1.016	70	1,741,888	1/10	174,189	2.42
61	L1	L2	100	1.016	70	1,741,888	1/4	435,472	6.05
70	I1	I2	100	1.016	70	1,741,888	1/2	870,944	12.10
50	N3	N4	100	1.016	70	1,741,888	3/4	1,306,416	18.14

Table C.1b: The normal load conditions and cycles administered for the scar development tests on unpeened aluminium alloy 2024 T351 in contact with aluminium alloy 2024 T351 and subjected to an axial stress amplitude of 100 MPa.

Specimen (no.)	Bridges		Normal stress (MPa)	1/2 normal load (kN)	Axial stress (MPa)	Life expectancy (no.)	Life proportion (no.)	Cycles administered (no.)	Timing expected (hr)
	Top (no.)	Bottom (no.)							
26	D2	D1	10	0.102	100	298,836	1/10	29,884	0.83
23	E2	E1	10	0.102	100	298,836	1/4	74,709	2.08
24	A4	A3	10	0.102	100	298,836	1/2	149,418	4.15
25	C4	C3	10	0.102	100	298,836	3/4	224,127	6.23
31	A2	A1	40	0.406	100	193,561	1/10	19,356	0.27
28	B4	B3	40	0.406	100	193,561	1/4	48,390	0.67
29	C2	C1	40	0.406	100	193,561	1/2	96,781	2.69
30	B2	B1	40	0.406	100	193,561	3/4	145,171	4.03
32	D4	D3	100	1.016	100	479,201	1/10	47,920	1.33
33	F2	F1	100	1.016	100	479,201	1/4	119,800	3.33
34	F4	F3	100	1.016	100	479,201	1/2	239,601	6.66
35	E4	E3	100	1.016	100	479,201	3/4	359,401	9.98

Table C.1c: The normal load conditions and cycles administered for the scar development tests on unpeened aluminium alloy 2024 T351 in contact with aluminium alloy 2024 T351 and subjected to an axial stress amplitude of 125 MPa.

Specimen (no.)	Bridges		Normal stress (MPa)	1/2 normal load (kN)	Axial stress (MPa)	Life expectancy (no.)	Life proportion (no.)	Cycles administered (no.)	Timing expected (hr)
	Top (no.)	Bottom (no.)							
42	K3	K4	10	0.102	125	546,587	1/10	54,659	0.76
45	I3	I4	10	0.102	125	546,587	1/4	136,647	1.90
46	M1	M2	10	0.102	125	546,587	1/2	273,294	3.80
48	J1	J2	10	0.102	125	546,587	3/4	409,940	5.69
67	Q3	Q4	60	0.610	125	83,704	1/10	8,370	0.12
52	P3	P4	60	0.610	125	83,704	1/4	20,926	0.29
47	O3	O4	60	0.610	125	83,704	1/2	41,852	0.58
60	N1	N2	60	0.610	125	83,704	3/4	62,778	0.87
65	G3	G4	100	1.016	125	145,848	1/10	14,585	0.20
44	H3	H4	100	1.016	125	145,848	1/4	36,462	0.51
62	Q1	Q2	100	1.016	125	145,848	1/2	72,924	1.01
71	M3	M4	100	1.016	125	145,848	3/4	109,386	1.52

C.2 PEENED

Table C.2a: The normal load conditions and cycles administered for the scar development tests on peened aluminium alloy 2024 T351 in contact with aluminium alloy 2024-T351 and subjected to an axial stress amplitude of 70 MPa.

Specimen (no.)	Bridges Top (no.)	Bridges Bottom (no.)	Normal stress (MPa)	1/2 normal load (kN)	Axial stress (MPa)	Life expectancy (no.)	Life proportion (no.)	Cycles administered (no.)	Timing expected (hr)
15P	T3	T4	10	0.102	70	6,131,072	1/10	613,107	8.52
27P	Z3	Z4	10	0.102	70	6,131,072	1/4	1,532,768	21.29
16P	X1	X2	10	0.102	70	4,579,328	1/2	2,289,664	31.80
20P	W1	W2	10	0.102	70	6,131,072	3/4	4,598,304	63.87
32P	AC1	AC2	60	0.610	70	4,579,328	1/10	457,933	6.36
18P	V1	V2	60	0.610	70	4,579,328	1/4	1,144,832	15.90
14P	T1	T2	60	0.610	70	6,131,072	1/2	3,065,536	42.58
17P	Y1	Y2	60	0.610	70	4,579,328	3/4	3,434,496	47.70
43P	AH3	AH4	100	1.016	70	5,000,000	1/10	500,000	6.94
19P	V3	V4	100	1.016	70	5,000,000	1/4	1,250,000	17.36
26P	Z1	Z2	100	1.016	70	5,000,000	1/2	2,500,000	34.72
28P	AA1	AA2	100	1.016	70	5,000,000	3/4	3,750,000	52.08

Table C.2b: The normal load conditions and cycles administered for the scar development tests on peened aluminium alloy 2024 T351 in contact with aluminium alloy 2024-T351 and subjected to an axial stress amplitude of 100 MPa.

Specimen (no.)	Bridges Top (no.)	Bridges Bottom (no.)	Normal stress (MPa)	1/2 normal load (kN)	Axial stress (MPa)	Life expectancy (no.)	Life proportion (no.)	Cycles administered (no.)	Timing expected (hr)
45P	AI3	AI4	10	0.102	100	5,000,000	1/10	500,000	6.94
22P	X1	X2	10	0.102	100	5,000,000	1/4	1,250,000	17.36
12P	S1	S2	10	0.102	100	5,000,000	1/2	2,500,000	34.72
17P	U3	U4	40	0.406	100	1,976,448	1/10	197,645	2.75
49P	AJ1	AJ2	40	0.406	100	1,976,448	1/4	494,112	6.86
34P	AD1	AD2	40	0.406	100	1,976,448	2/4	988,224	13.73
29P	AA3	AA4	40	0.406	100	1,976,448	3/4	1,482,336	20.59
16P	U1	U2	100	1.016	100	1,330,816	1/10	133,082	1.85
30P	AB1	AB2	100	1.016	100	1,330,816	1/4	332,704	4.62
39P	AF3	AF4	100	1.016	100	1,330,816	2/4	665,408	9.24
24P	Y1	Y2	100	1.016	100	1,330,816	3/4	998,112	13.86

Table C.2c: The normal load conditions and cycles administered for the scar development tests on peened aluminium alloy 2024 T351 in contact with aluminium alloy 2024-T351 and subjected to an axial stress amplitude of 125 MPa.

Specimen	Bridges		Normal stress	1/2 normal load	Axial stress	Life expectancy	Life proportion	Cycles administered	Timing expected
(no.)	Top (no.)	Bottom (no.)	(MPa)	(kN)	(MPa)	(no.)	(no.)	(no.)	(hr)
38P	AF1	AF2	10	0.102	125	1,786,240	1/10	178,624	2.48
44P	AI1	AI2	10	0.102	125	1,786,240	1/4	446,560	6.20
13P	S3	S4	10	0.102	125	1,786,240	2/4	893,120	12.40
13P	S3	S4	10	0.102	125	1,786,240	3/4	1,339,680	18.61
33P	AC3	AC4	60	0.610	125	1,129,792	1/10	112,979	1.57
42P	AH1	AH2	60	0.610	125	1,129,792	1/4	282,448	3.92
23P	X3	X4	60	0.610	125	1,129,792	2/4	564,896	7.85
40P	AG1	AG2	60	0.610	125	1,129,792	3/4	847,344	11.77
36P	AE1	AE2	100	1.016	125	434,432	1/10	43,443	0.60
37P	AE3	AE4	100	1.016	125	434,432	1/4	108,608	1.51
21P	W3	W4	100	1.016	125	434,432	2/4	217,216	3.02
25P	Y3	Y4	100	1.016	125	434,432	3/4	325,824	4.53

APPENDIX D

PROGRAM: SCAR DATA ANALYSIS

This Visual Basic program, written by Miss S. Scorey, post processes data collected by the UBM data logging system. First, the profiles are levelled about a centre line, then these are smoothed. The maximum notch depth found, the length of that notch and the height of the highest peaks either side of that notch are evaluated. These values are collated together with plots of the profiles and close ups of the areas of interest. The means and medians for every combination of load and proportion of life are saved to a separate file.

D.1 VISUAL BASIC CODE

```
Option Explicit

'This module contains the code that manipulates each PR file found in a given location.

Sub ConvertPRFiles()

'Opens up each PR file found in a given location.
'Deletes rows 1 and 2 if data starts on row 3 and saves as an excel file.

Dim MyPath As String
Dim MyName As String
Dim i As Integer
Dim IsPeened As Boolean
Dim PeenedStr As String
Dim MyMPa As String

IsPeened = False
MyMPa = "\70 MPa"

PeenedStr = "Unpeened"
If IsPeened = True Then PeenedStr = "Peened"

Application.DisplayAlerts = False
```

'MyPath will need to be modified if the locations of the files changes.

'Set MyPath to be the top folder (should contain the folders Unpeened and Peened and the file Template.xls).

MyPath = "C:\Documents and Settings\Rachel Edwards\My Documents\My PhD\Unpeened\Levelled\" & PeenedStr & MyMPa

```
With Application.FileSearch
  .NewSearch
  .LookIn = MyPath & "\PR files"
  .SearchSubFolders = False
  .FileType = msoFileTypeAllFiles
  .Execute
  For i = 1 To .FoundFiles.Count
    Application.Workbooks.Open (.FoundFiles(i))
    MyName = Mid(ActiveWorkbook.Name, 1, 6) & ".xls"
    If IsPeened = True Then MyName = Mid(ActiveWorkbook.Name, 1, 7) & ".xls"
    If Mid(Cells(1, 1).Value, 1, 1) = "P" Then
      Rows(1).Delete
      Rows(1).Delete
    End If
    ActiveWorkbook.SaveAs (MyPath & "\XLS files\" & MyName)
    ActiveWorkbook.Close
  Next
End With
Application.DisplayAlerts = True

End Sub
```

```
Option Explicit

'This module contains the code that levels the data.

Sub LevelData()

Dim i As Integer
Dim j As Integer
Dim k As Integer
Dim xArr(2801) As Integer
Dim yArr(2801) As Single
Dim MyPath As String
Dim MyPath1 As String
Dim MyPath2 As String
Dim SavePath As String
Dim MyName1 As String
Dim MyName2 As String
Dim MyMPa As String
Dim MyS As Single
Dim MyI As Single
Dim WkBkA As Workbook
Dim WkBkB As Workbook
Dim AvgDf As Single
Dim MaxDf As Single

MyMPa = "70 MPa"

'MyPath will need to be modified if the location of the files changes.

'Set MyPath to be the top folder (should contain the folders Unpeened and Peened and
the file Template.xls).

MyPath = "C:\Documents and Settings\Rachel Edwards\My Documents\My PhD\Surface
Roughness"
MyPath1 = MyPath & "\Raw data\Unpeened\" & MyMPa
MyPath2 = MyPath & "\Levelled data\Unpeened\" & MyMPa & "\XLS files"

SavePath = MyPath1 & "\Levelled\"

ThisWorkbook.Sheets("Diffs").Cells(1, 1).Value = "File"
ThisWorkbook.Sheets("Diffs").Cells(1, 2).Value = "AvgAbsDf"
ThisWorkbook.Sheets("Diffs").Cells(1, 3).Value = "MaxAbsDf"

Application.DisplayAlerts = False

With Application.FileSearch
```

'Find all the files in the folder MyPath1.

```
    .NewSearch
    .LookIn = MyPath1
    .SearchSubFolders = False
    .Execute
```

'For each of the files found.

```
    For j = 1 To .FoundFiles.Count
```

'Open the workbook.

```
        Application.Workbooks.Open (.FoundFiles(j))
```

'Create the levelled data file name.

```
        MyName1 = Mid(ActiveWorkbook.Name, 1, 5) & "LS" & ".xls"
        MyName2 = Mid(ActiveWorkbook.Name, 1, 5) & "L" & ".xls"
        ActiveWorkbook.SaveAs (SavePath & MyName1)
```

'Put each data point and its corresponding row in the worksheet, into arrays. yArr and xArr, respectively.

```
        For i = 1 To 2801
          xArr(i) = i
          yArr(i) = Cells(i, 1)
        Next
```

'Use the LinEst function to find the slope and the intercept of the data as a function of the row that its in (i.e. the 'error' as a function of its position in the data).

```
        MyS = Excel.WorksheetFunction.Index(Excel.WorksheetFunction.LinEst(yArr, xArr),
1)
        MyI = Excel.WorksheetFunction.Index(Excel.WorksheetFunction.LinEst(yArr, xArr),
2)
```

'Remove the error component from the data by subtracting y = mx + c from each value (where m is the slope MyS, c is the intercept MyI and x is the row).

```
        For i = 1 To 2801
          Cells(i, 2).Value = Cells(i, 1).Value - (MyS * i + MyI)
        Next
```

'Standardise the data by shifting all values up or down by the average amount the values differ from zero.

```
        For i = 1 To 2801
          Cells(i,          3).Value          =          Cells(i,          2).Value          -
Excel.WorksheetFunction.Average(Range(Cells(1, 2), Cells(2801, 2)))
        Next
```

```
'Remove the original data and the non-standardised data.

    Columns(1).Select
    Selection.Delete
    Columns(1).Select
    Selection.Delete

'Format the data to three decimal places (and set precision to match).

    Selection.NumberFormat = "0.000"
    ActiveWorkbook.PrecisionAsDisplayed = True

'Save and close the levelled data.

    ActiveWorkbook.Save
    ThisWorkbook.Sheets("Diffs").Cells(j + 1, 1).Value = MyName1
    If Dir(MyPath2 & "\" & MyName2) <> "" Then
      Set WkBkA = ActiveWorkbook
      Application.Workbooks.Open (MyPath2 & "\" & MyName2)
      Set WkBkB = ActiveWorkbook
      Range(Cells(1, 1), Cells(2801, 1)).Select
      If Mid(Cells(1, 1), 1, 1) = "P" Then Range(Cells(3, 1), Cells(2803, 1)).Select
      Selection.Copy
      WkBkA.Activate
      Cells(1, 2).Select
      ActiveSheet.Paste
      For k = 1 To 2801
        Cells(k, 3).Value = Abs(Cells(k, 2).Value - Cells(k, 1).Value)
      Next
      AvgDf = Excel.WorksheetFunction.Average(Range(Cells(1, 3), Cells(2801, 3)))
      MaxDf = Excel.WorksheetFunction.Max(Range(Cells(1, 3), Cells(2801, 3)))
      ThisWorkbook.Sheets("Diffs").Cells(j + 1, 2).Value = AvgDf
      ThisWorkbook.Sheets("Diffs").Cells(j + 1, 3).Value = MaxDf
      WkBkB.Close
    End If
    ActiveWorkbook.Close
  Next
End With
Application.DisplayAlerts = True

End Sub
```

```
Option Explicit

'This module contains the code that performs the analysis of the data.

Sub Analysis()

Private IsPeened As String

Dim GetSD As Variant
Dim MySD As String
Dim MyPath As String
Dim NewPath As String
Dim ResPath As String
Dim MyFileName As String
Dim i As Integer
Dim j As Integer
Dim k As Integer
Dim kArray(2801) As Single
Dim WA As Workbook
Dim WB As Workbook
Dim TempFile As String
Dim Pressure As Integer

'Set IsPeened to either 'Unpeened' or 'Peened' to run the analysis for the unpeend or peened data.

IsPeened = "Unpeened"

'MyPath will need to be modified if the location of the files changes.

'Set MyPath to be the top folder (should contain the folders Unpeened and Peened and the file Template.xls).

MyPath = "C:\Documents and Settings\Rachel Edwards\My Documents\My PhD\Surface Roughness\"

'Find the template file.

TempFile = MyPath & "Template.xls"

'Turn off alerts.

Application.DisplayAlerts = False

'Find out what value of SD to use.

GetSD = InputBox("Please enter the smoothing constant (SD):" & vbCrLf & "NB: this must be an integer in the range 0-100.", "Smoothing constant", "20")
```

```
'If the input box is left blank, then end.

If GetSD = "" Then Exit Sub

'Convert the text in the input box to an integer number.

MySD = Int(GetSD)

For i = 1 To 3

'For each Pressure value.

   Select Case i
      Case 1
         Pressure = 70
      Case 2
         Pressure = 100
      Case 3
         Pressure = 125
   End Select

'Set NewPath to look in the correct folder (i.e. Unpeened or Peened, then the Pressure
for this loop).

   NewPath = MyPath & IsPeened & "\" & Pressure & " MPa"

'Set ResPath to the file path where results files are to be saved.

   ResPath = NewPath & "\Results~" & MySD & "\"

'If the folder named ResPath doesn't exist, create it.

   If Len(Dir(ResPath, vbDirectory)) = 0 Then MkDir (ResPath)

   With Application.FileSearch

'Find all the files in the folder 'XLS files' in NewPath.

      .NewSearch
      .LookIn = NewPath & "\XLS files"
      .SearchSubFolders = False
      .Execute

'For each of the files found.

      For j = 1 To .FoundFiles.Count

'Open the workbook.

         Application.Workbooks.Open (.FoundFiles(j))

'Give the currently open workbook a 'codename' WA, so it can be referenced easily in the
code.
```

```
        Set WA = ActiveWorkbook
```

'Create the results file name, based on the letter 'R', plus he original file name, plus the current value of pressure.

```
        MyFileName = "R" & Mid(WA.Name, 1, 7) & MySD & ".xls"
        If IsPeened = "Unpeened" Then MyFileName = "R" & Mid(WA.Name, 1, 6) &
MySD & ".xls"
```

'Open the template file (identified earlier as TempFile).

```
        Application.Workbooks.Open (TempFile)
```

'Give the template file a 'codename' WB, so it can be referenced easily in the code.

```
        Set WB = ActiveWorkbook
```

'Save the template using the file name created earlier.

```
        WB.SaveAs (ResPath & MyFileName)
```

'Enter the value of SD into the results file.

```
        Sheets("data").Select
        Cells(1, 5).Value = MySD
```

'Copy the data from the original file.

```
        WA.Activate
        Range(Cells(1, 1), Cells(2801, 1)).Select
        Selection.Copy
```

'Paste into the results file.

```
        WB.Activate
        Cells(243, 2).Select
        ActiveSheet.Paste
```

'If the file is measured from the right hand side of the block, invert the results.

```
        If Mid(WA.Name, Len(WA.Name) - 6, 1) = "R" Then
           For k = 0 To 2800
              kArray(k) = Cells(k + 243, 2).Value
           Next
           For k = 0 To 2800
              Cells(k + 243, 2).Value = kArray(2800 - k)
           Next
        End If
```

'Close the original data file.

```
        WA.Close
```

```
'Find the depth, width, minimum, maximum, etc.

          Call FindValues

'Transfer the values from the results file to this file.

          Call TransferValues(Pressure)

'Close the results file.

          WB.Close

'Save this workbook.

          ThisWorkbook.Save
       Next
    End With

 Next

 End Sub
```

Sub FindValues()

```
Dim i As Integer
Dim j As Integer
Dim k As Integer
Dim xMin As Single
Dim xMax As Single
Dim jMin As Integer
Dim jMax As Integer
Dim max As Single

'Find the scar depth, and the row containing the deepest part of the scar.

j = 243

'Set max to equal the deepest part of the scar.

max = Cells(243, 3).Value
For i = 244 To 3043

'If the value of cell(i,3) is less than max, set max equal to the value of cell(i,3).

   If max > Cells(i, 3).Value Then
      max = Cells(i, 3).Value
      j = i
   End If
Next

'j is the row number of the cell containing the deepest point of the scar and remains so for the rest of the subroutine.

'Set jMin to 636 rows (~1.27 mm) before the centre of the scar.

jMin = j – 636

'If jMin is less than the number of the first row of data, set jMin equal to the number of the first row of data (243).

If jMin < 243 Then jMin = 243

'Set jMax to 636 rows (~1.27 mm) after the centre of the scar.

jMax = j + 636

'If jMax is greater than the number of the first row of data, set jMax equal to the number of the first row of data (3043).

If jMax > 3043 Then jMax = 3043
```

'Change the named ranges ZoomX, ZoomR and ZoomS to contain only the data 636 rows either side of the deepest part of the scar.

```
ActiveWorkbook.Names.Add Name:="ZoomX", RefersToR1C1:="=data!R" & jMin & "C1:R" & jMax & "C1"
ActiveWorkbook.Names.Add Name:="ZoomR", RefersToR1C1:="=data!R" & jMin & "C2:R" & jMax & "C2"
ActiveWorkbook.Names.Add Name:="ZoomS", RefersToR1C1:="=data!R" & jMin & "C3:R" & jMax & "C3"
```

'Set the range of values to appear on the x-axis, based on the lowest and highest values of x (ie from the value of cell(jMin,1) to the value of cell(jMax,1)).

```
xMin = (Int(10 * Cells(jMin, 1).Value)) / 10
xMax = (Int(10 * Cells(jMax, 1).Value + 1)) / 10
```

'Set the x-axis on chart zoom to range from xMin to xMax.

```
Charts("zoom").Select
   With ActiveChart.Axes(xlCategory)
      .MinimumScale = xMin
      .MaximumScale = xMax
   End With
```

'Return to the data sheet.

```
Sheets("data").Select
```

'Enters the x position of the deepest part of the scar into cell (243,9).

```
Cells(243, 9).Value = Cells(j, 1).Value
```

'Enters the magnitude of the depth of the scar into cell (243,10).

```
Cells(243, 10).Value = Abs(max)
```

'Find the position of the start of the scar, (i.e. the last point before the scar where the data crosses the x-axis).

```
i = j
Do Until Cells(i, 3).Value > 0#
   i = i - 1
   If i < 243 Then
      Cells(244, 9).Value = "N/A"
      Exit Do
   End If
Loop
```

'Enters the x position of the start of the scar into cell (244,9).

```
Cells(244, 9).Value = Cells(i, 1).Value
```

```
'Find the maximum height before the scar.

k = 243
max = Cells(243, 3).Value

'Starts 636 rows (~1.27mm) before deepest point of scar.

For i = jMin To j
   If max < Cells(i, 3).Value Then
      max = Cells(i, 3).Value
      k = i
   End If
Next

'Enters the x position of the maximum height before the scar into cell(247,9).

Cells(247, 9).Value = Cells(k, 1).Value

'Enters the magnitude of the maximum height before the scar into cell(247,10).

Cells(247, 10).Value = max

'Find the position of the end of the scar, (i.e. the first 'point after the scar where the data
crosses the x-axis).

i = j
Do Until Cells(i, 3).Value > 0#
   i = i + 1
   If i > 3043 Then
      Cells(245, 9).Value = "N/A"
      Exit Do
   End If
Loop

'Enters the x position of the end of the scar into cell (245,9).

Cells(245, 9).Value = Cells(i, 1).Value

'Find the maximum height after the scar.

k = j
max = Cells(j, 3).Value

'Ends 636 rows (~1.27mm) after deepest point of scar.

For i = j To jMax
   If max < Cells(i, 3).Value Then
      max = Cells(i, 3).Value
      k = i
   End If
Next
```

Enters the x position of the maximum height after the scar into cell (248,9).

```
Cells(248, 9).Value = Cells(k, 1).Value

'Enters the magnitude of the maximum height before the scar into cell (248,10).

Cells(248, 10).Value = max

'Save the results workbook.

ActiveWorkbook.Save

End Sub
```

```
Sub TransferValues(Pressure As Integer)

'Transfer the values from the results file into the 'Results' sheet of this file.

Dim i As Integer
Dim SheetB As Worksheet
Dim WBName As String

'Set WBName equal to the first seven letters of the results file.

WBName = Mid(ActiveWorkbook.Name, 1, 7)

'Set SheetB equal to the data sheet in the active results file.

Set SheetB = ActiveWorkbook.Sheets("data")

'Activate this workbook and select the 'Results' sheet.

   ThisWorkbook.Activate
   Sheets("Results").Activate

'Find the first empty row on the sheet.

   i = 2
   Do Until Cells(i, 1).Value = ""
      i = i + 1
   Loop

'Add the value stored in WBName to the 1st cell.

   Cells(i, 1).Value = WBName

'Add the specimen number to the 2nd cell (2nd, 3rd and 4th characters of WBName).

   Cells(i, 2).Value = Mid(WBName, 2, 3)

'Add the Top/Bottom postiion to the 3rd cell.

   Cells(i, 3).Value = "=Mid(RC[-2], 5, 1)"

'Add the Left/Middle/Right position to the 4th cell.

   Cells(i, 4).Value = "=Mid(RC[-3], 6, 1)"

'Add the Front/Middle/Back position to the 5th cell.

   Cells(i, 5).Value = "=Mid(RC[-4], 7, 1)"
   If IsPeened = "Unpeened" Then
```

```
'The values in cells 2 to 5 need to be modified if the file contains unpeened data.

      Cells(i, 2).Value = Mid(WBName, 2, 2)
      Cells(i, 3).Value = "=Mid(RC[-2], 4, 1)"
      Cells(i, 4).Value = "=Mid(RC[-3], 5, 1)"
      Cells(i, 5).Value = "=Mid(RC[-4], 6, 1)"
   End If

'Lookup the values of Normal, Axial and L_Prop in the sheet 'Specimens', using the
specimen number in cell 2.

   Cells(i, 6).Value = "=vlookup(RC[-4], Specimens!SpecRange, 2,false)"
   Cells(i, 7).Value = "=vlookup(RC[-5], Specimens!SpecRange, 3,false)"
   Cells(i, 8).Value = "=vlookup(RC[-6], Specimens!SpecRange, 4,false)"

'Transfer the SD from the results file.

   Cells(i, 9).Value = SheetB.Cells(1, 5).Value

'Transfer the Depth/Width/etc. values from the results file.

   Cells(i, 10).Value = SheetB.Cells(243, 10).Value
   Cells(i, 11).Value = SheetB.Cells(243, 9).Value
   Cells(i, 12).Value = SheetB.Cells(244, 9).Value
   Cells(i, 13).Value = SheetB.Cells(245, 9).Value
   Cells(i, 14).Value = SheetB.Cells(246, 9).Value
   Cells(i, 15).Value = SheetB.Cells(247, 9).Value
   Cells(i, 16).Value = SheetB.Cells(247, 10).Value

'Calculate the total height of the maximum before the scar, by adding the height from 0 to
the maximum scar depth.

   Cells(i, 17).Value = Cells(i, 16).Value + Cells(i, 10).Value
   Cells(i, 18).Value = SheetB.Cells(248, 9).Value
   Cells(i, 19).Value = SheetB.Cells(248, 10).Value

'Calculate the total height of the maximum after the scar, by adding the height from 0 to
the maximum scar depth.

   Cells(i, 20).Value = Cells(i, 19).Value + Cells(i, 10).Value

End Sub
```

Sub CreateChartZoom(ScarMax As Integer)

```
'
   ActiveWorkbook.Names.Add Name:="ZoomX", RefersToR1C1:="=data!R2" & j - 636 &
"C1:R" & j + 636 & "C1"
'
   Sheets("chart").Copy Before:=Sheets("data")
   ActiveChart.SetSourceData Source:=Sheets("data").Range("A253:C3033")

End Sub
```

APPENDIX E

RESULTS: FRETTING FATIGUE LIFE

Failure is defined as the fracture of the specimens, rather than the achievement of a given crack length.

E.1 UNPEENED

Table E.1a: The number of cycles to failure for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to an axial stress amplitude of 70 MPa.

Specimen (no.)	Normal stress (MPa)	Axial stress (MPa)	Cycles to failure (no.)
55	10	70	5,099,520
106	10	70	3,733,888
105	20	70	1,598,400
56	40	70	1,224,704
59	60	70	886,320
109	80	70	1,033,504
54	100	70	3,273,088
104	100	70	1,741,888
107	100	70	1,253,056

Table E.1b: The number of cycles to failure for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to an axial stress amplitude of 100 MPa.

Specimen (no.)	Normal stress (MPa)	Axial stress (MPa)	Cycles to failure (no.)
8	10	100	316,952
2	10	100	321,077
11	20	100	377,392
16	40	100	176,027
9	40	100	229,077
10	60	100	252,756
6	60	100	134,366
18	80	100	364,468
5	80	100	204,560
19	100	100	553,971
20	100	100	404,431

Table E.1c: The number of cycles to failure for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to an axial stress amplitude of 125 MPa.

Specimen (no.)	Normal stress (MPa)	Axial stress (MPa)	Cycles to failure (no.)
39	10	125	546,587
40	20	125	327,497
38	40	125	83,867
37	60	125	133,992
100	80	125	176,427
102	80	125	91,600
101	100	125	137,632
108	100	125	145,848

E.2 PEENED

Table E.2a: The number of cycles to failure for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to an axial stress amplitude of 70 MPa.

Specimen (no.)	Normal stress (MPa)	Axial stress (MPa)	Cycles to failure (no.)
9P	10	70	6,131,072+
2P	60	70	4,579,328 G
5P	100	70	5,000,000+

Table E.2b: The number of cycles to failure for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to an axial stress amplitude of 100 MPa.

Specimen (no.)	Normal stress (MPa)	Axial stress (MPa)	Cycles to failure (no.)
2P	10	100	5,000,000+
8P	40	100	1,976,448
4P	100	100	1,330,816

Table E.2c: The number of cycles to failure for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to an axial stress amplitude of 125 MPa.

Specimen (no.)	Normal stress (MPa)	Axial stress (MPa)	Cycles to failure (no.)
3P	10	125	1,786,240 P
10P	60	125	1,129,792
1P	100	125	434,432 G

+ Test stopped before failure in the fretting test section.

G Test stopped due to failure not in the fretting test section, but in the grips.

P Test stopped due to failure not in the fretting test section, but in a locating pin.

APPENDIX F

RESULTS: FRICTION DATA

These friction parameters were taken from hysteresis loops plotted for every test which can be found in Appendix H. The coefficient of friction is a ratio of the friction force and half of the normal load, definition of which can be found in Section 4.2.2.2.

F.1 UNPEENED

Table F.1a: The friction forces, amplitudes and coefficients for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to an axial stress amplitude of 70 MPa.

Specimen (no.)	Normal stress (MPa)	Axial stress (MPa)	Friction force max. (kN)		Friction force min. (kN)		Friction amplitude (kN)			Friction coefficient (μ)		
			Top	Bottom	Top	Bottom	Top	Bottom	Average	Top	Bottom	Average
106	10	70	0.147	0.148	-0.098	-0.073	0.122	0.111	0.117	1.204	1.089	1.147
105	20	70	0.503	0.555	-0.233	-0.058	0.368	0.306	0.337	1.810	1.508	1.659
56	40	70	0.478	0.594	-0.393	-0.310	0.435	0.452	0.444	1.070	1.112	1.091
59	60	70	0.374	0.348	-0.366	-0.357	0.370	0.353	0.361	0.607	0.578	0.593
109	80	70	0.688	1.624	-0.512	-1.174	0.600	1.399	0.999	0.738	1.721	1.230
104	100	70	0.471	0.601	-0.478	-0.336	0.475	0.468	0.471	0.467	0.461	0.464

Table F.1b: The friction forces, amplitudes and coefficients for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to an axial stress amplitude of 100 MPa.

Specimen (no.)	Normal stress (MPa)	Axial stress (MPa)	Friction force max. (kN)		Friction force min. (kN)		Friction amplitude (kN)			Friction coefficient (μ)		
			Top	Bottom	Top	Bottom	Top	Bottom	Average	Top	Bottom	Average
8	10	100	0.166	0.316	-0.072	-0.132	0.119	0.224	0.171	1.169	2.207	1.688
2	10	100	0.207	0.232	-0.081	-0.157	0.144	0.194	0.169	1.421	1.914	1.667
11	20	100	0.299	0.383	-0.126	-0.253	0.212	0.318	0.265	1.045	1.564	1.304
16	40	100	0.432	0.490	-0.293	-0.377	0.363	0.433	0.398	0.893	1.067	0.980
9	40	100	0.559	0.626	-0.412	-0.462	0.486	0.544	0.515	1.195	1.339	1.267
10	60	100	0.416	0.526	-0.324	-0.424	0.370	0.475	0.422	0.607	0.779	0.693
6	60	100	0.640	0.468	-0.409	-0.301	0.524	0.385	0.454	0.860	0.631	0.746
18	80	100	0.280	0.599	-0.336	-0.400	0.308	0.500	0.404	0.379	0.615	0.497
5	80	100	0.638	0.555	-0.506	-0.456	0.572	0.505	0.539	0.704	0.622	0.663
19	100	100	0.533	0.714	-0.545	-0.534	0.539	0.624	0.582	0.531	0.614	0.572
20	100	100	0.488	0.673	-0.576	-0.610	0.532	0.642	0.587	0.524	0.632	0.578

Table F.1c: The friction forces, amplitudes and coefficients for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to an axial stress amplitude of 125 MPa.

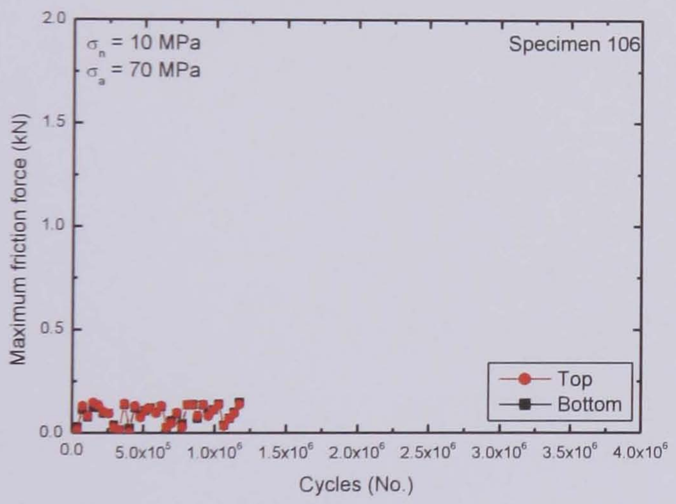
Specimen (no.)	Normal stress (MPa)	Axial stress (MPa)	Friction force max. (kN)		Friction force min. (kN)		Friction amplitude (kN)			Friction coefficient (μ)		
			Top	Bottom	Top	Bottom	Top	Bottom	Average	Top	Bottom	Average
39	10	125	0.234	0.752	-0.139	-0.082	0.186	0.417	0.302	1.834	4.106	2.970
40	20	125	0.412	0.556	-0.280	-0.159	0.346	0.357	0.352	1.703	1.759	1.731
38	40	125	0.933	0.763	-0.469	-0.433	0.701	0.598	0.650	1.725	1.472	1.598
37	60	125	0.951	0.971	-0.596	-0.456	0.774	0.714	0.744	1.269	1.171	1.220
100	80	125	0.803	0.954	-0.476	-0.510	0.639	0.732	0.685	0.787	0.900	0.843
101	100	125	1.143	1.281	-0.729	-0.614	0.936	0.947	0.942	0.921	0.932	0.927

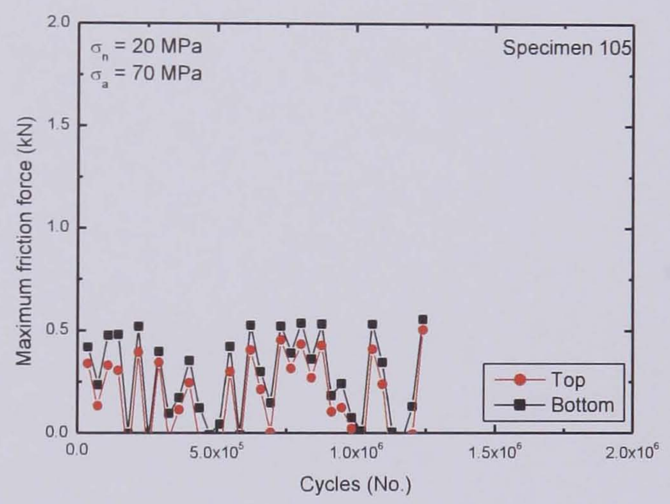
APPENDIX G

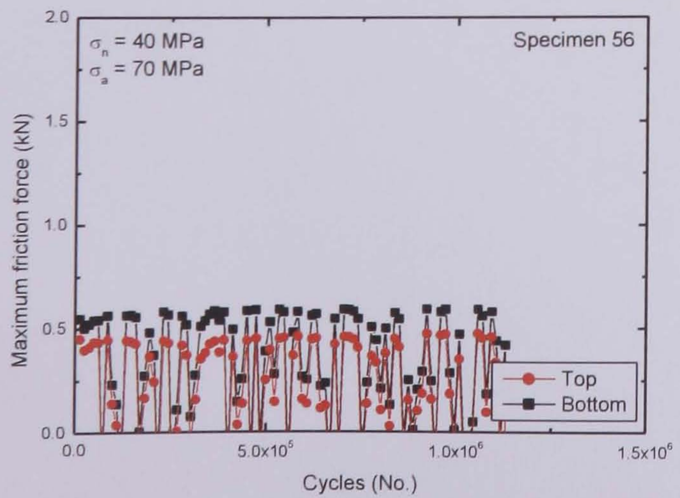
RESULTS: EVOLUTION OF MAXIMUM FRICTION VALUES

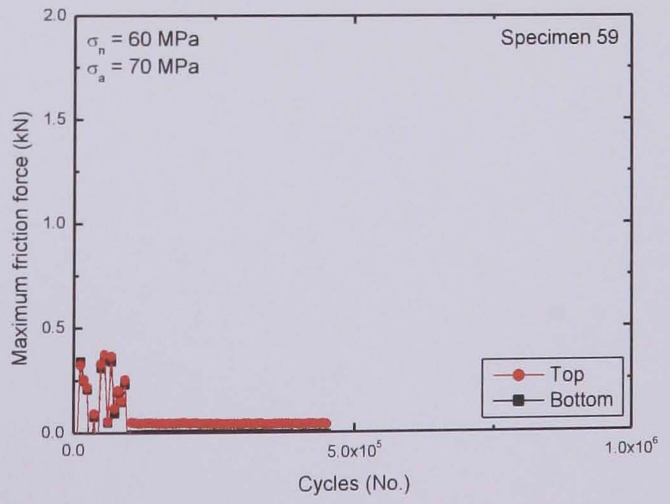
The evolution of the maximum friction force recorded over the life of every unpeened specimen, traced for both the top and bottom fretting pad.

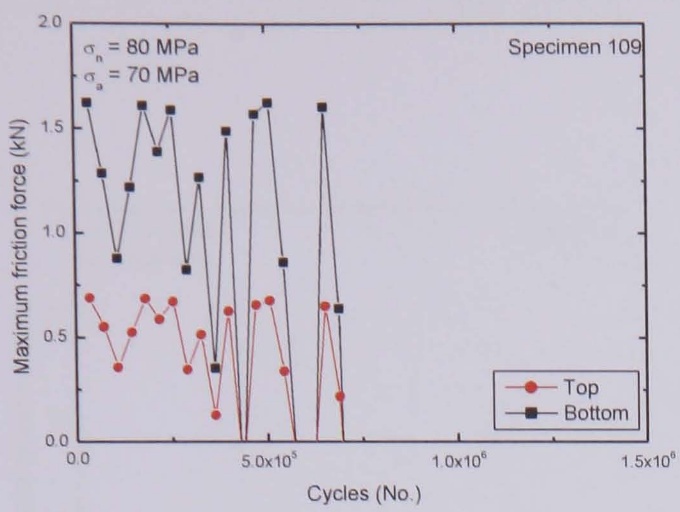
G.1 FRICTION MAXIMUM: σ_a = 70 MPa unpeened

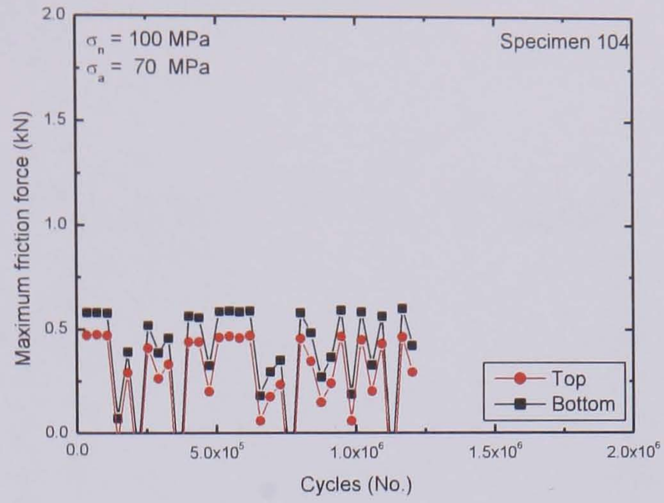




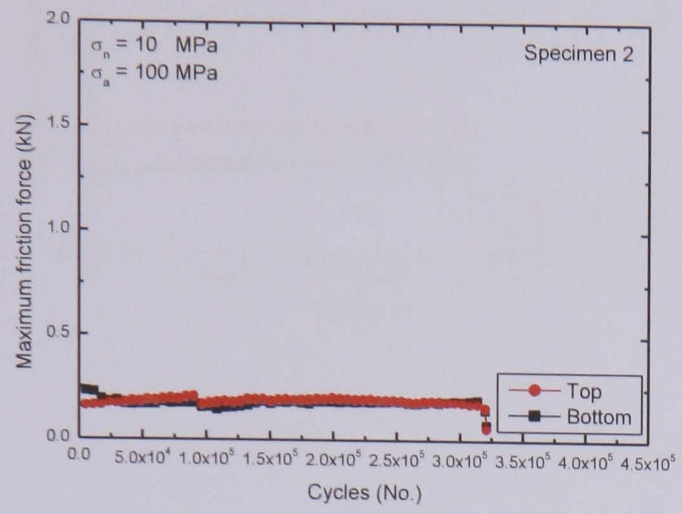


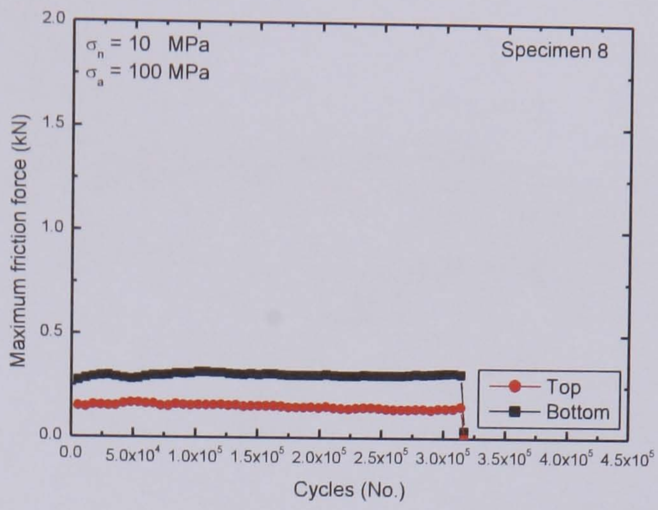


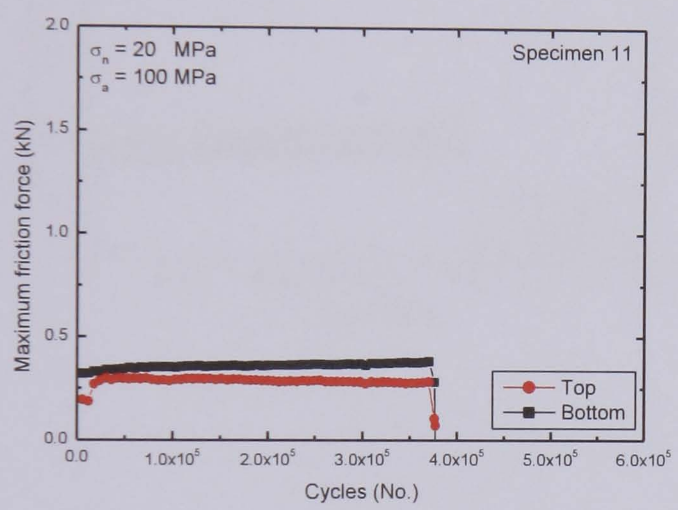

σn = 80 MPa
σa = 70 MPa
Specimen 109
Maximum friction force (kN)
Cycles (No.)
Top
Bottom

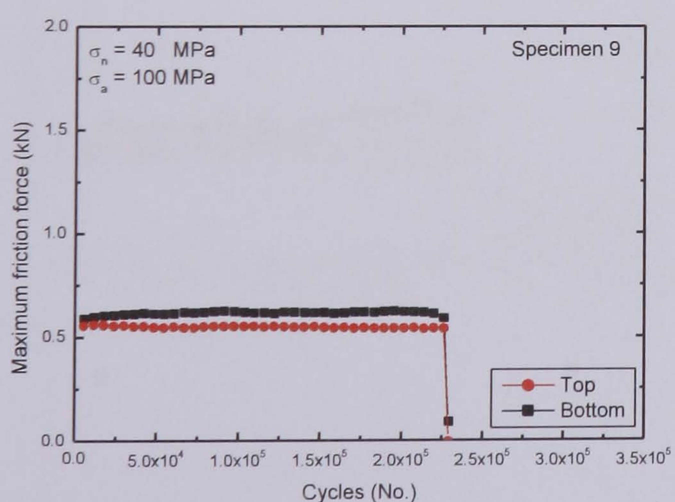

σn = 100 MPa
σa = 70 MPa
Specimen 104
Maximum friction force (kN)
Cycles (No.)
Top
Bottom

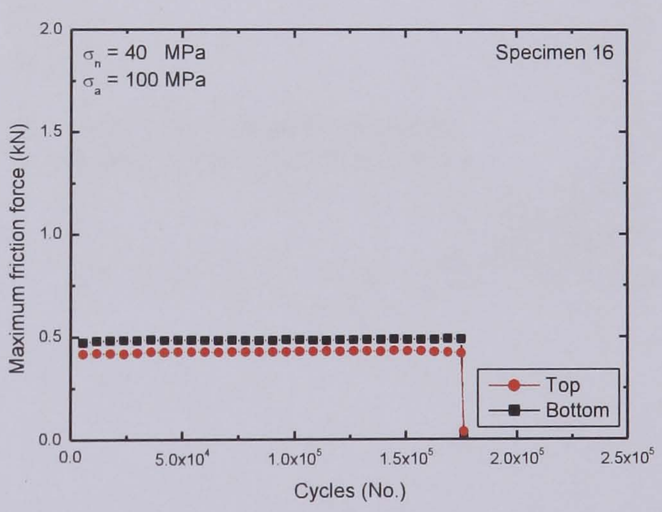
G.2 FRICTION MAXIMUM: σ_a = 100 MPa unpeened

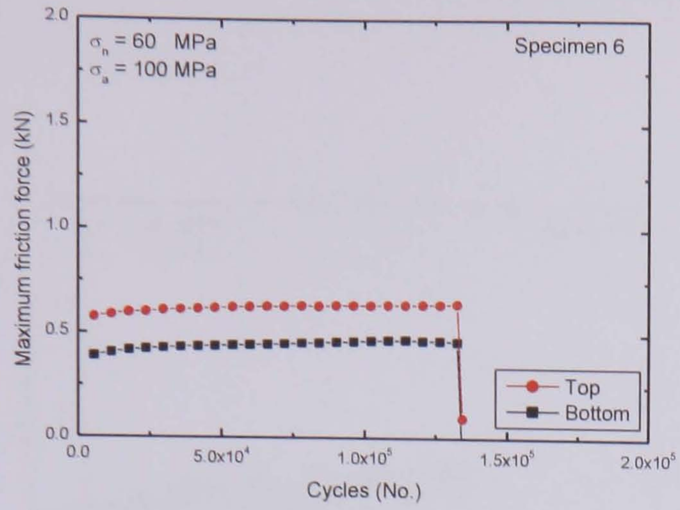


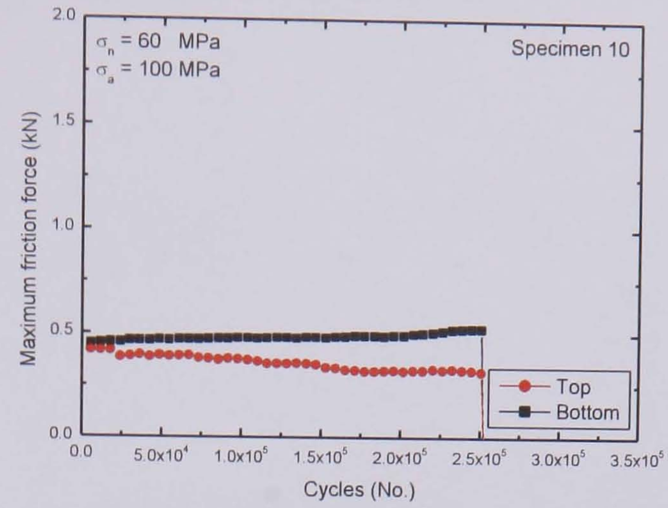


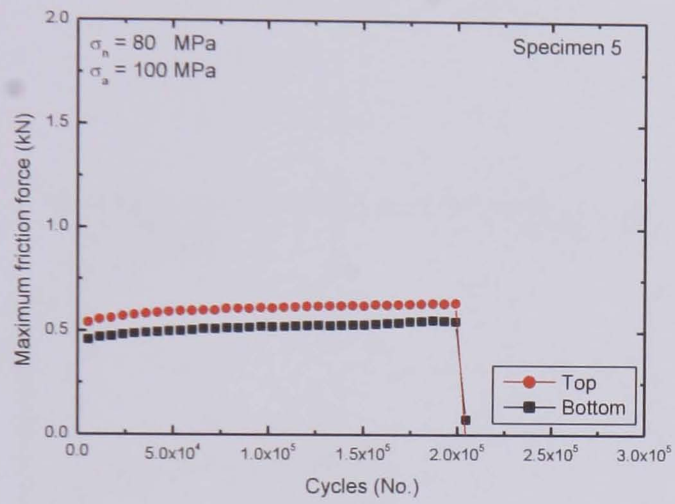


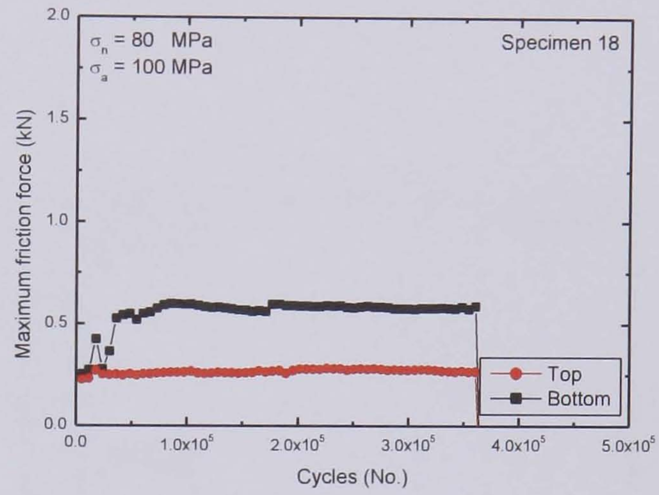


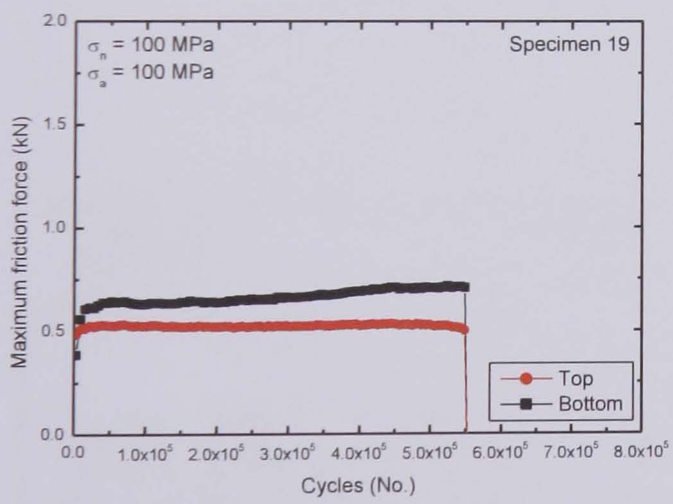


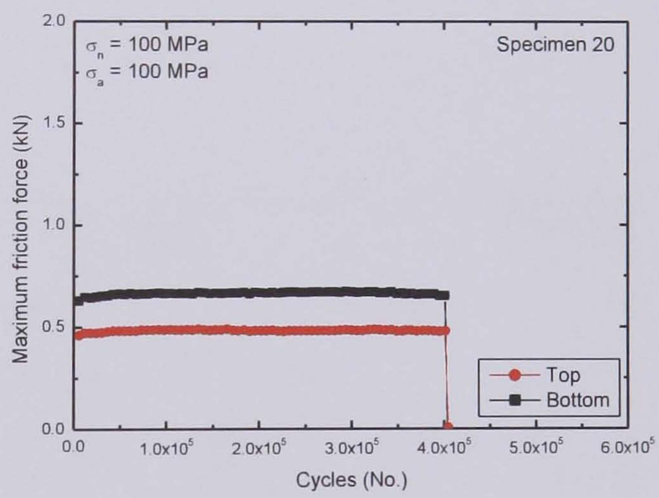

σn = 60 MPa
σa = 100 MPa
Specimen 6
Maximum friction force (kN)
Cycles (No.)
Top
Bottom


σn = 60 MPa
σa = 100 MPa
Specimen 10
Maximum friction force (kN)
Cycles (No.)
Top
Bottom

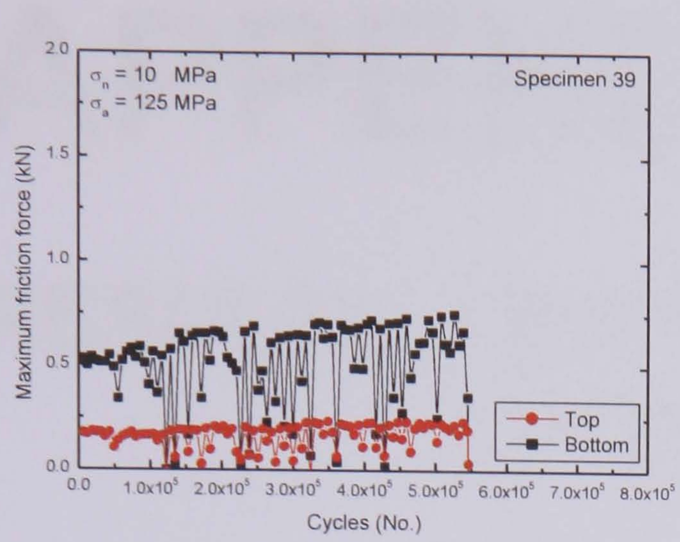

σn = 80 MPa
σa = 100 MPa
Specimen 5
Maximum friction force (kN)
Cycles (No.)
Top
Bottom

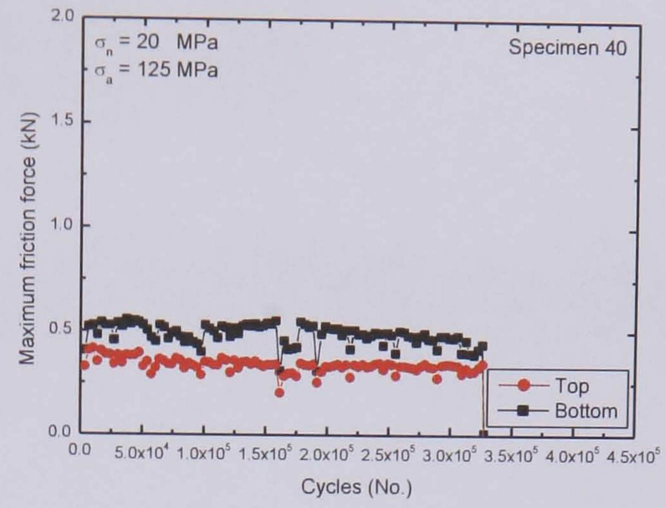

σn = 80 MPa
σa = 100 MPa
Specimen 18
Maximum friction force (kN)
Cycles (No.)
Top
Bottom

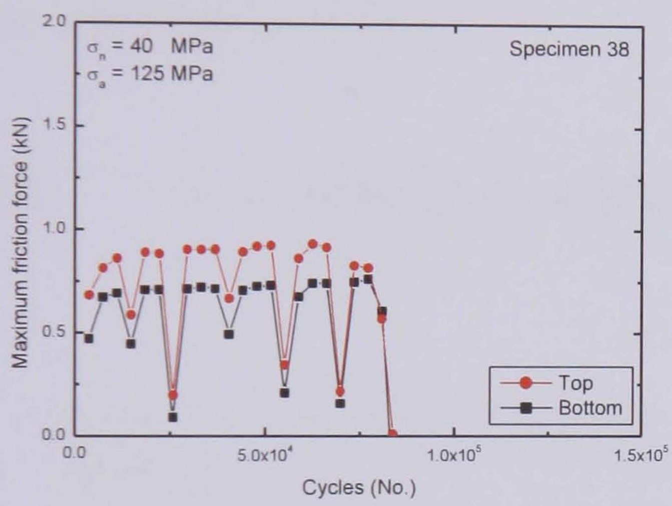

σn = 100 MPa
σa = 100 MPa
Specimen 19
Maximum friction force (kN)
Cycles (No.)
Top
Bottom

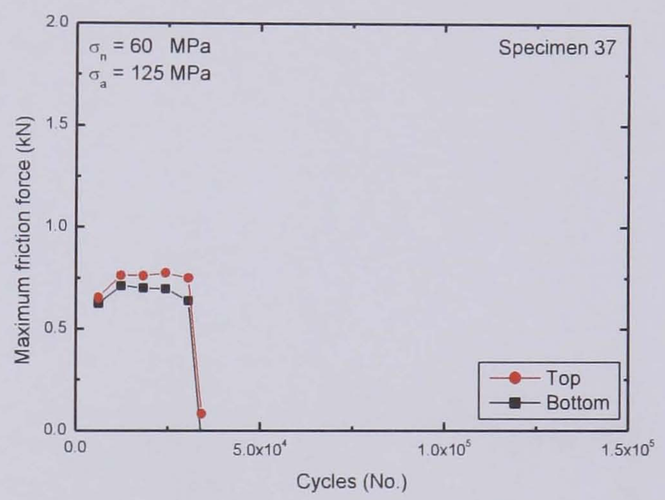

σn = 100 MPa
σa = 100 MPa
Specimen 20
Maximum friction force (kN)
Cycles (No.)
Top
Bottom

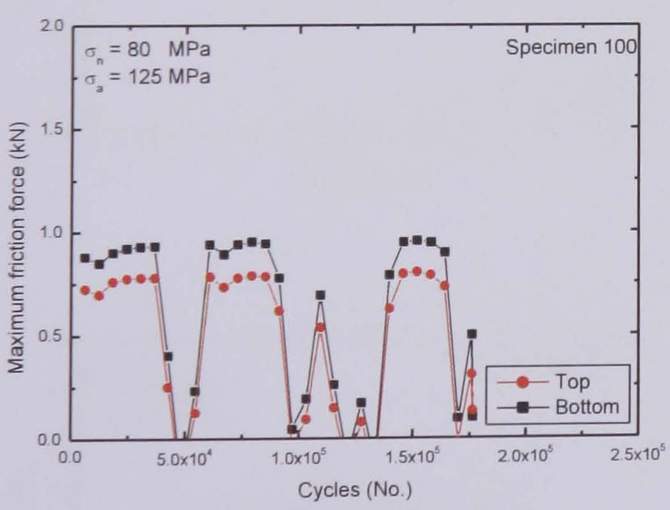
G.3 FRICTION MAXIMUM: σ_a = 125 MPa unpeened

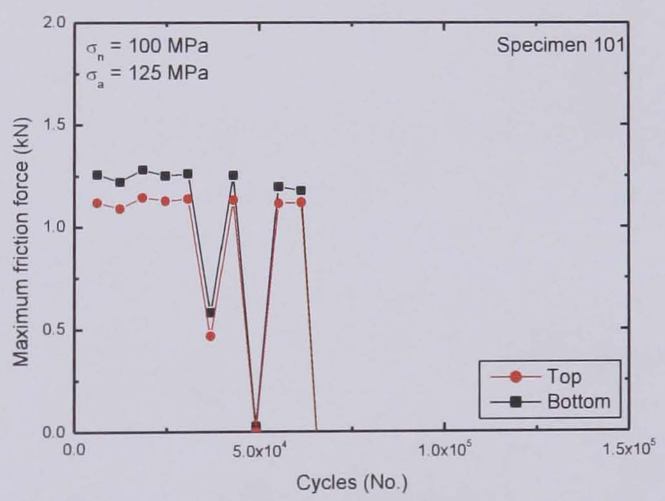










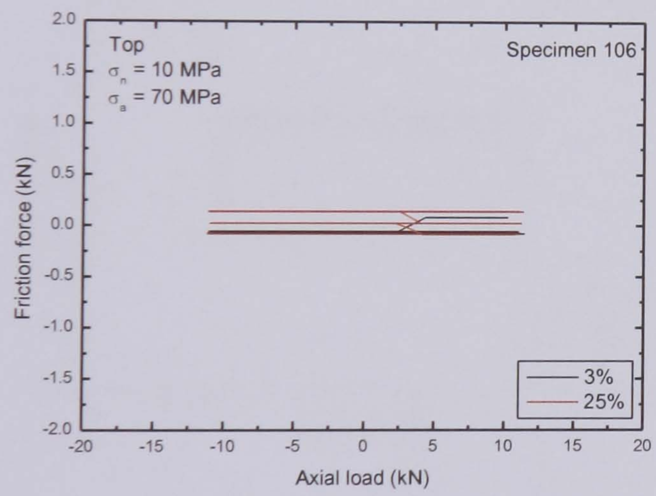


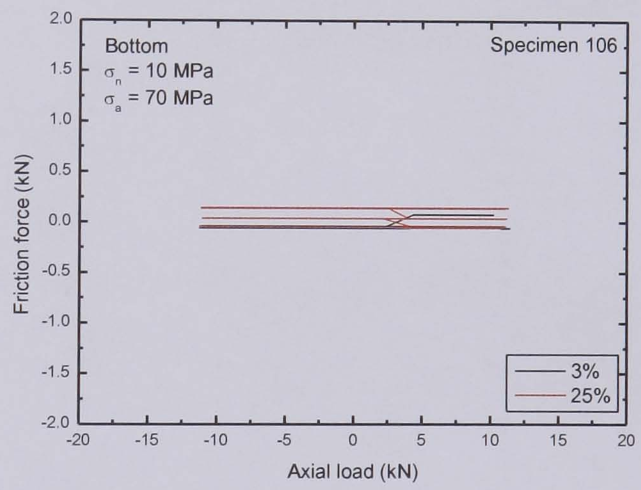
APPENDIX H

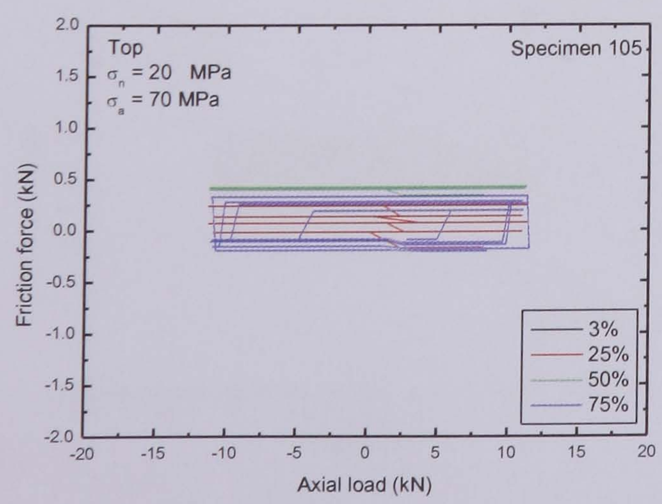
RESULTS: FRICTION HYSTERESIS LOOPS

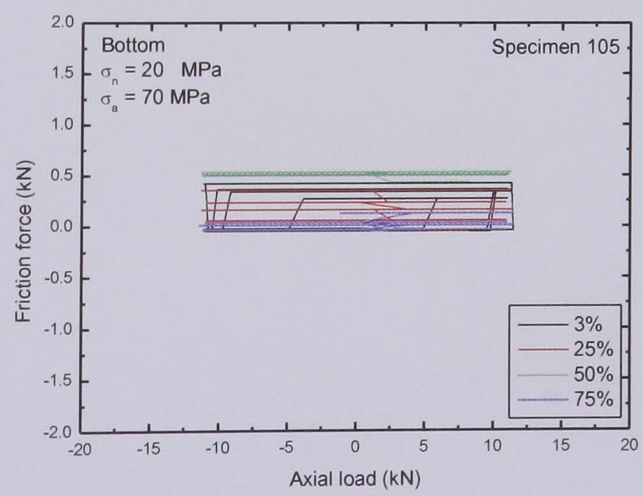
All hysteresis loops plotted for every test, including those that were distorted by the data logging system.

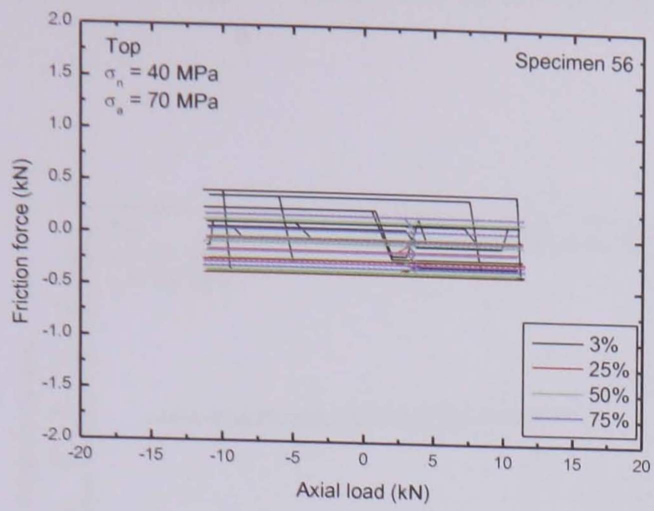
H.1 σ_a = 70 MPa unpeened

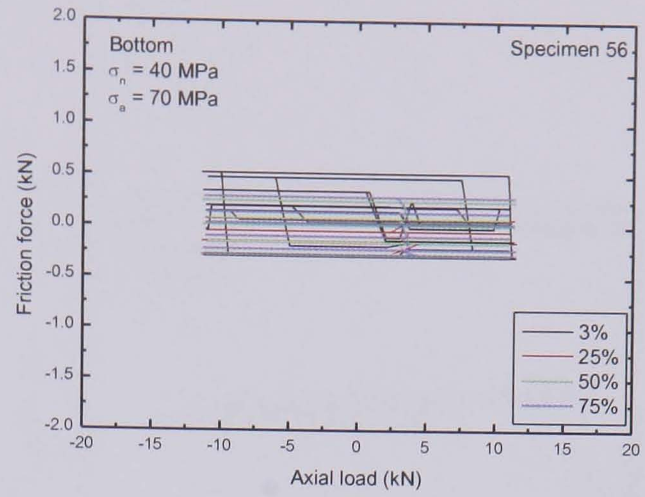


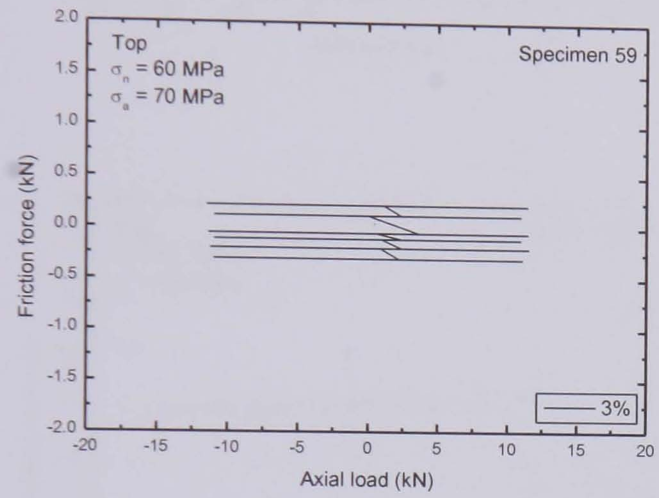


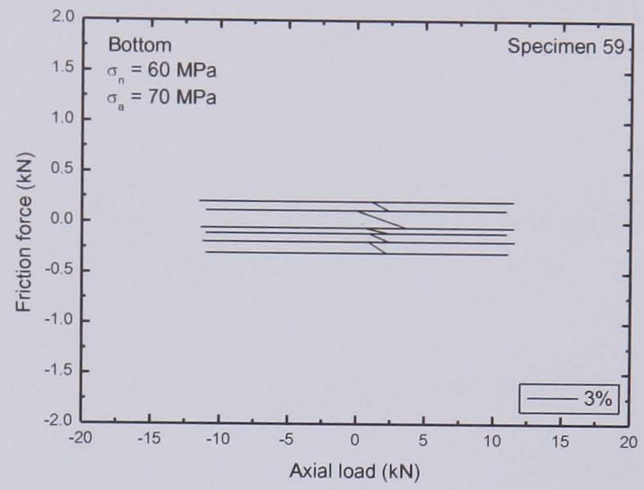


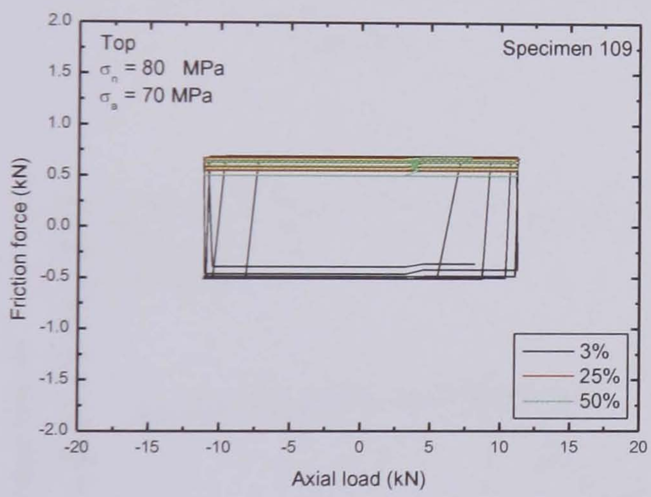


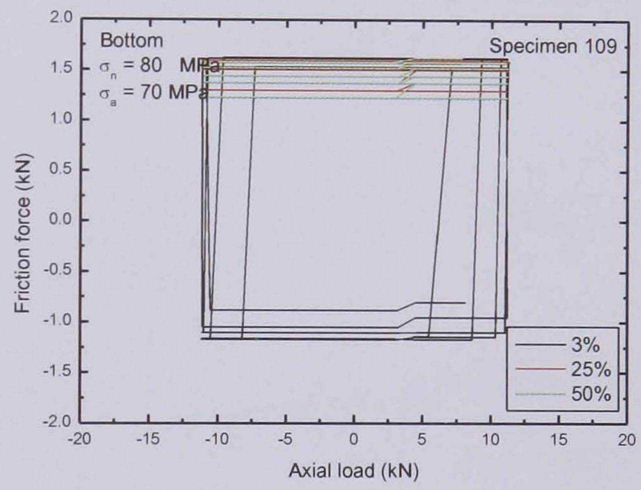

Top
σ_n = 40 MPa
σ_a = 70 MPa
Specimen 56
3%
25%
50%
75%
Friction force (kN)
Axial load (kN)

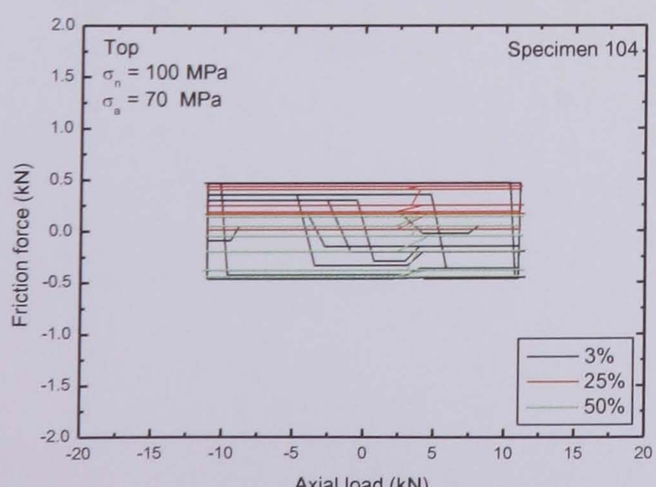

Bottom
σ_n = 40 MPa
σ_a = 70 MPa
Specimen 56
3%
25%
50%
75%
Friction force (kN)
Axial load (kN)

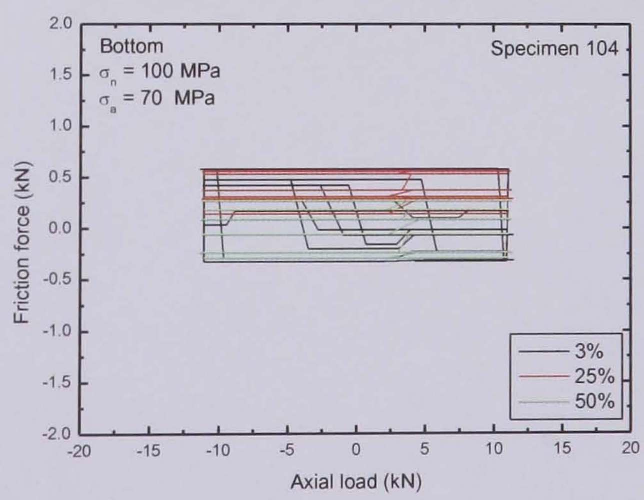

Top
σ_n = 60 MPa
σ_a = 70 MPa
Specimen 59
3%
Friction force (kN)
Axial load (kN)


Bottom
σ_n = 60 MPa
σ_a = 70 MPa
Specimen 59
3%
Friction force (kN)
Axial load (kN)

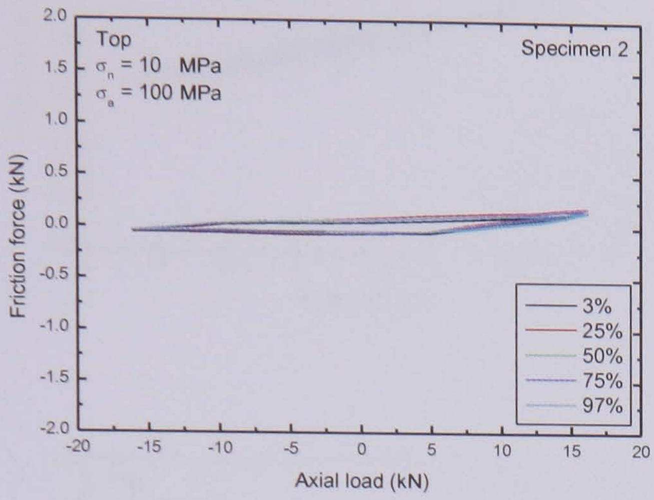

Top
σ_n = 80 MPa
σ_a = 70 MPa
Specimen 109
3%
25%
50%
Friction force (kN)
Axial load (kN)

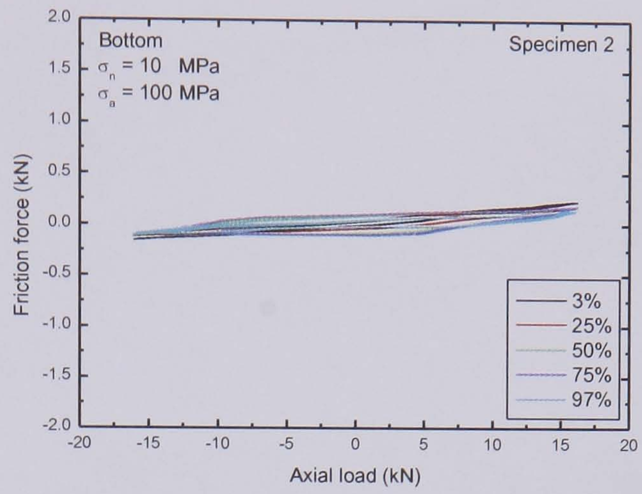

Bottom
σ_n = 80 MPa
σ_a = 70 MPa
Specimen 109
3%
25%
50%
Friction force (kN)
Axial load (kN)

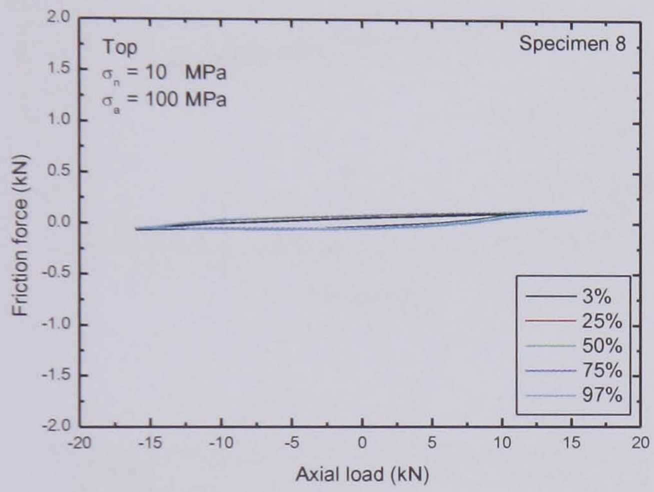

Top
σ_n = 100 MPa
σ_a = 70 MPa
Specimen 104
3%
25%
50%
Friction force (kN)
Axial load (kN)

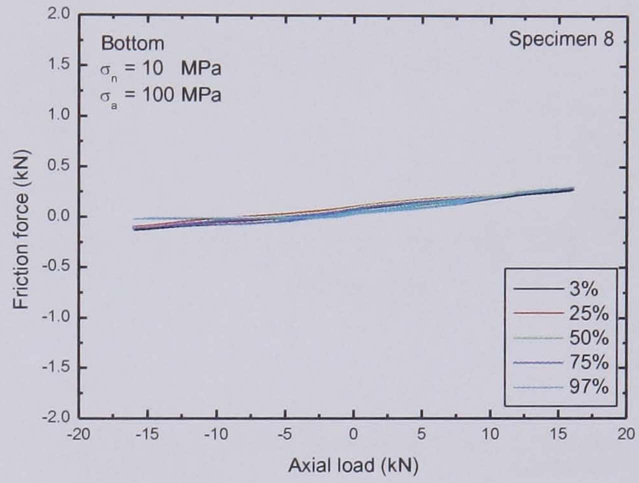

Bottom
σ_n = 100 MPa
σ_a = 70 MPa
Specimen 104
3%
25%
50%
Friction force (kN)
Axial load (kN)

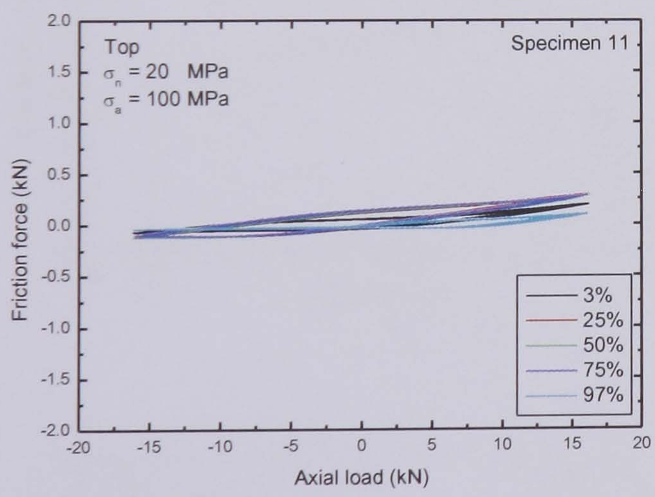
H.2 σ_a = 100 MPa unpeened

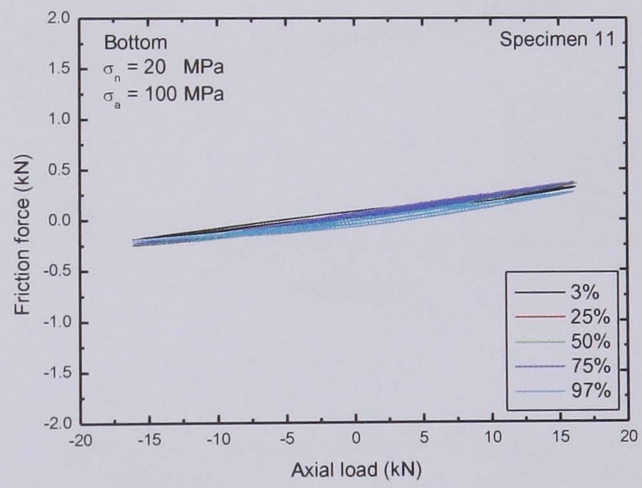


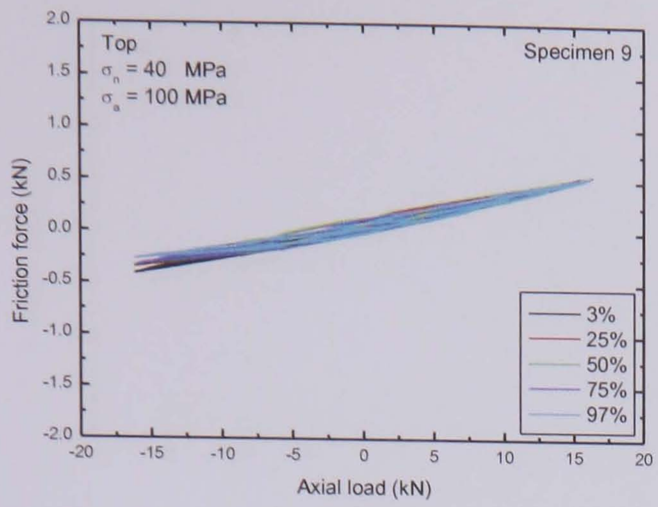


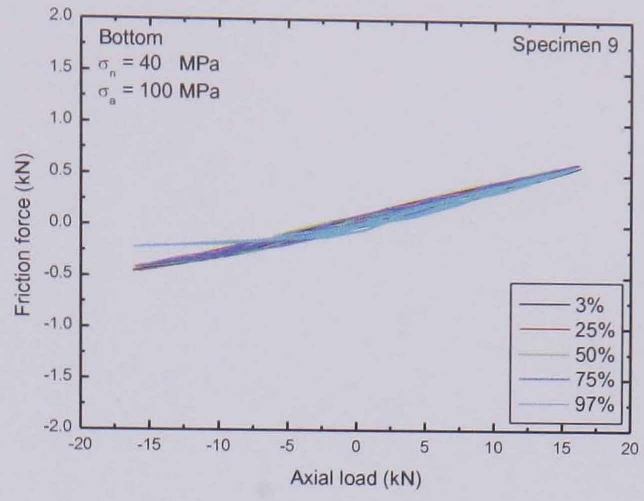


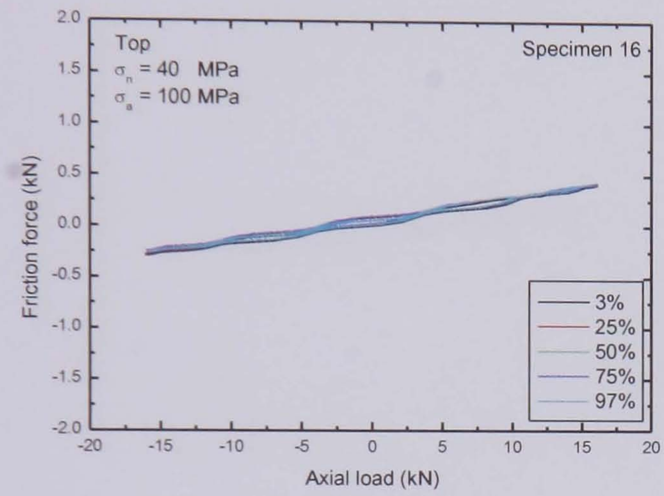


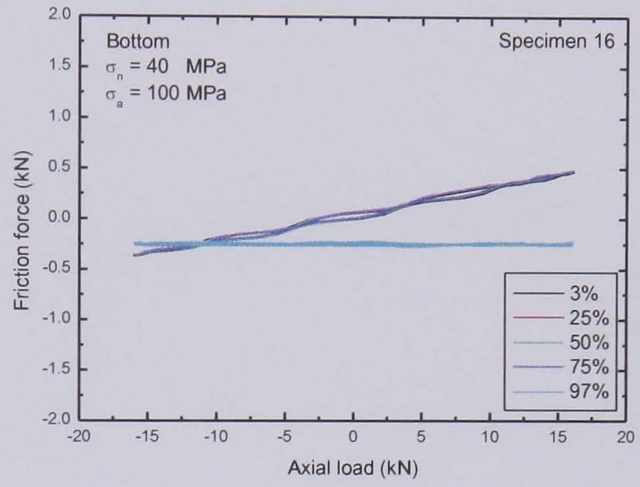


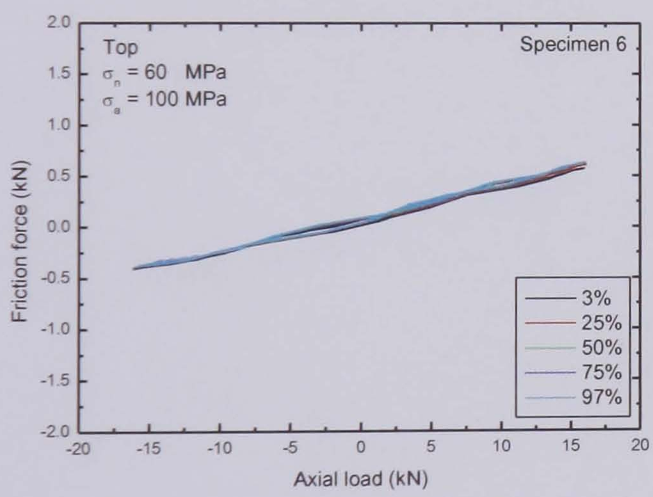


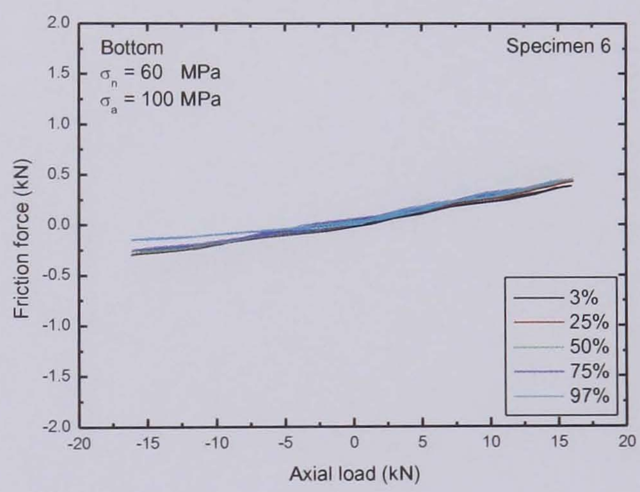

Top
σn = 40 MPa
σa = 100 MPa
Specimen 9
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

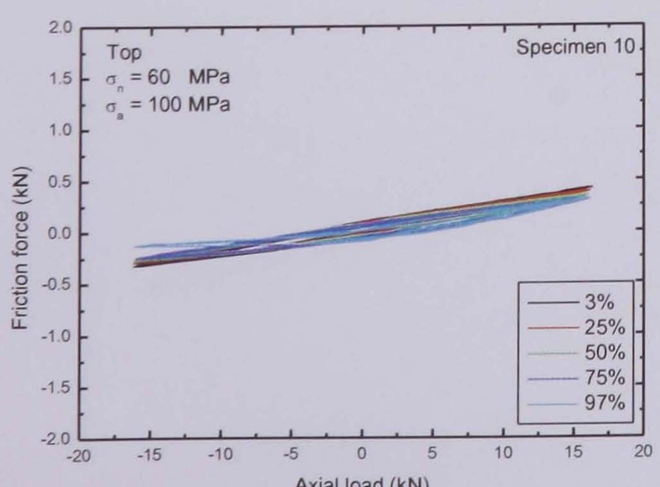

Bottom
σn = 40 MPa
σa = 100 MPa
Specimen 9
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

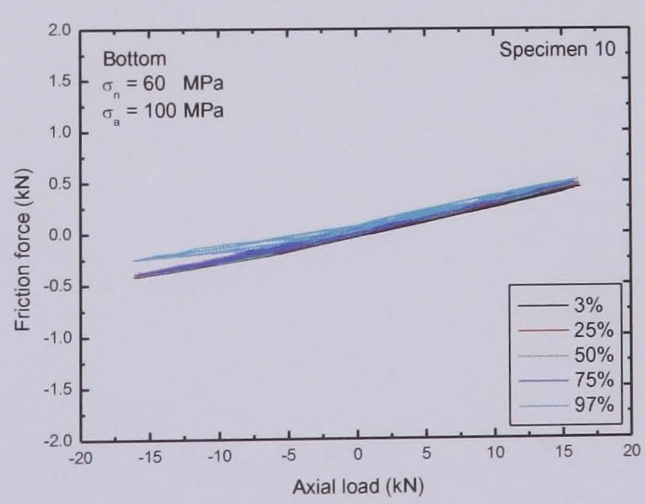

Top
σn = 40 MPa
σa = 100 MPa
Specimen 16
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

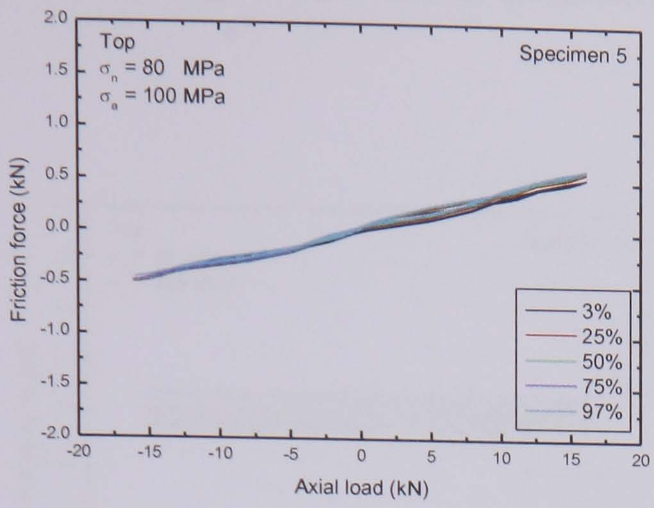

Bottom
σn = 40 MPa
σa = 100 MPa
Specimen 16
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

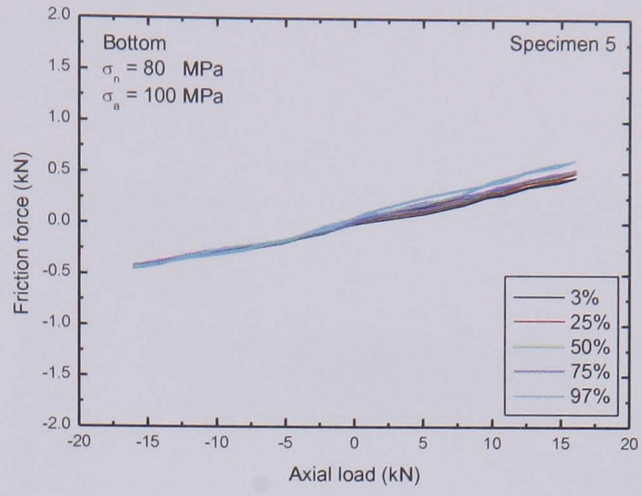

Top
σn = 60 MPa
σa = 100 MPa
Specimen 6
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

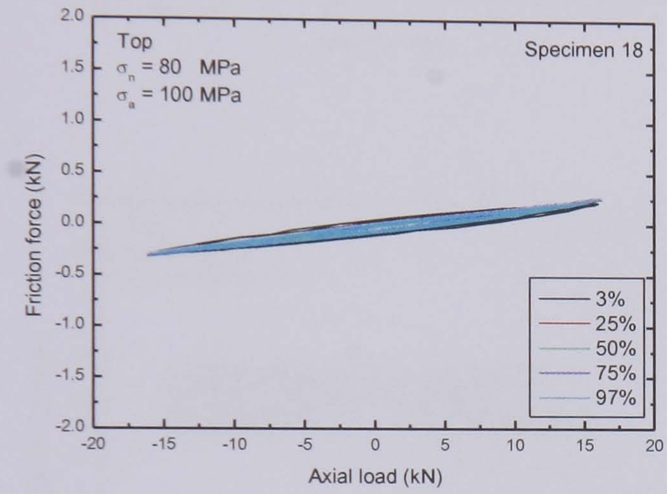

Bottom
σn = 60 MPa
σa = 100 MPa
Specimen 6
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

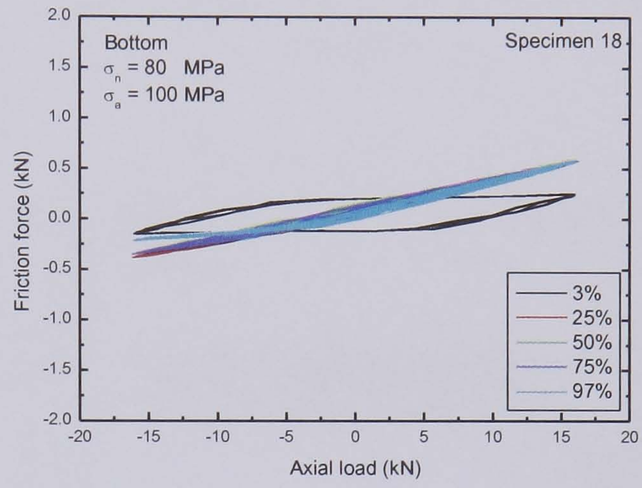

Top
σn = 60 MPa
σa = 100 MPa
Specimen 10
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

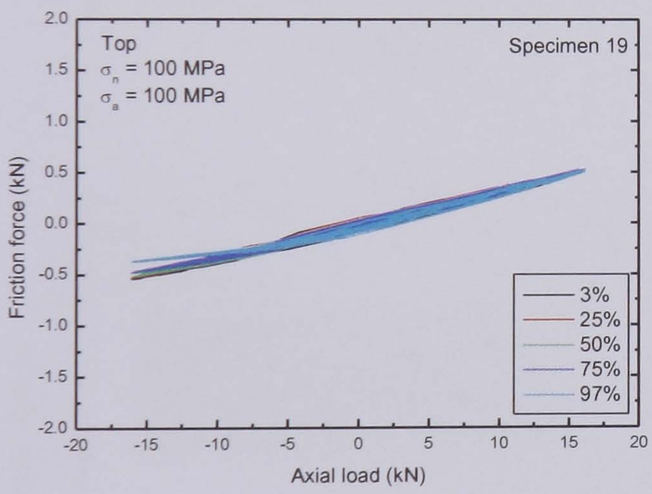

Bottom
σn = 60 MPa
σa = 100 MPa
Specimen 10
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

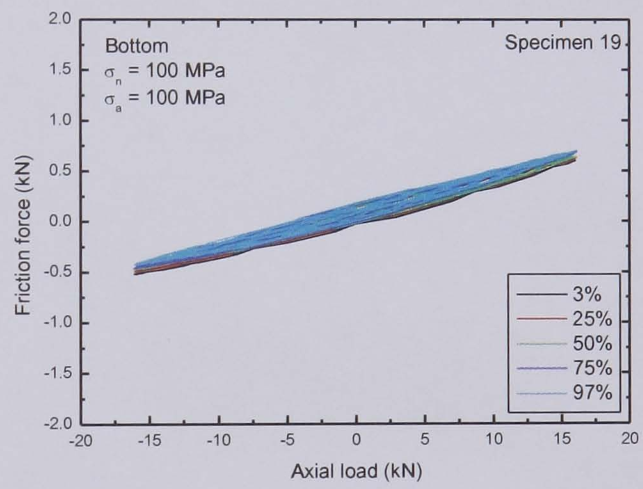

Top
σ_n = 80 MPa
σ_a = 100 MPa
Specimen 5
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

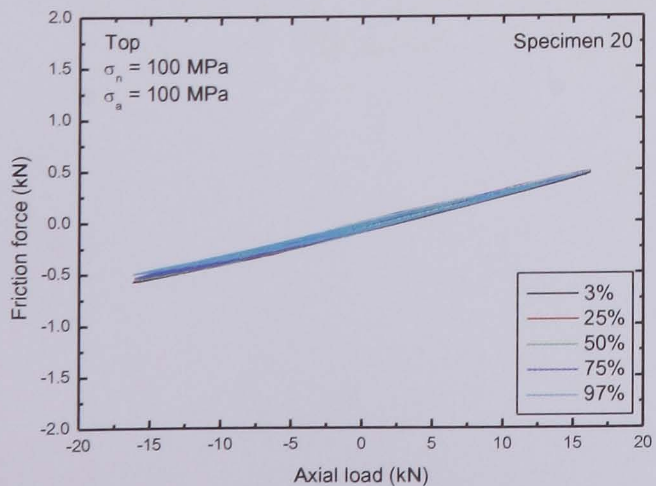

Bottom
σ_n = 80 MPa
σ_a = 100 MPa
Specimen 5
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

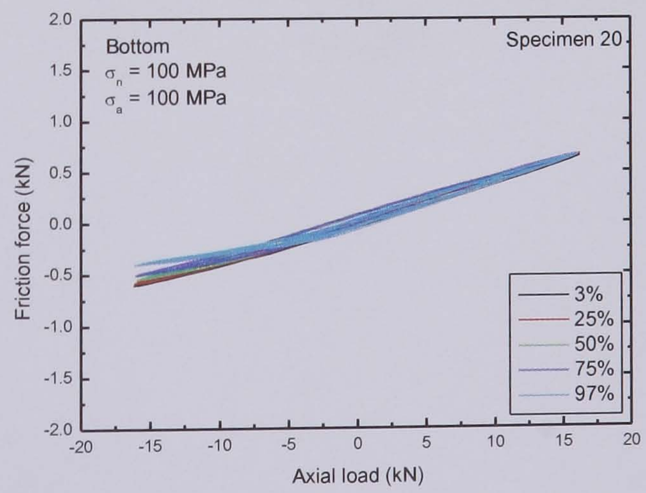

Top
σ_n = 80 MPa
σ_a = 100 MPa
Specimen 18
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%


Bottom
σ_n = 80 MPa
σ_a = 100 MPa
Specimen 18
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

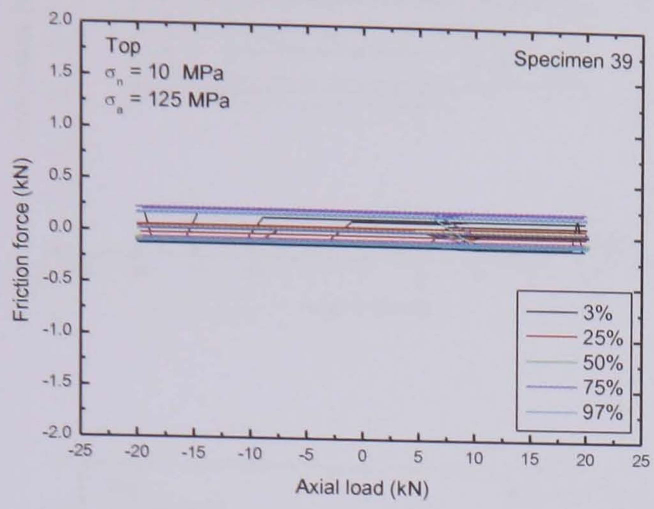

Top
σ_n = 100 MPa
σ_a = 100 MPa
Specimen 19
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

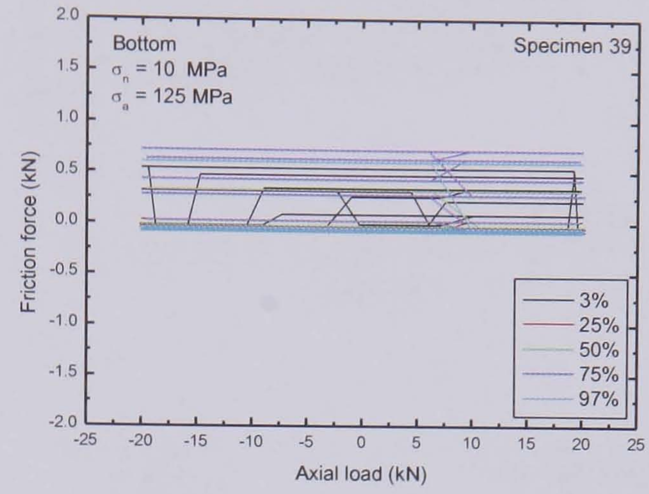

Bottom
σ_n = 100 MPa
σ_a = 100 MPa
Specimen 19
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

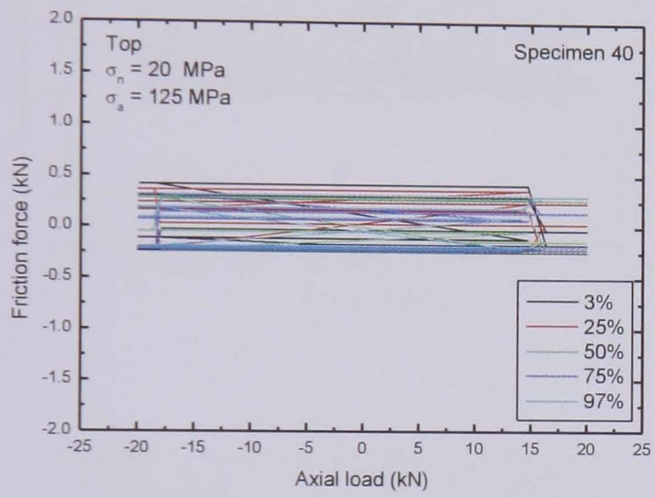

Top
σ_n = 100 MPa
σ_a = 100 MPa
Specimen 20
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

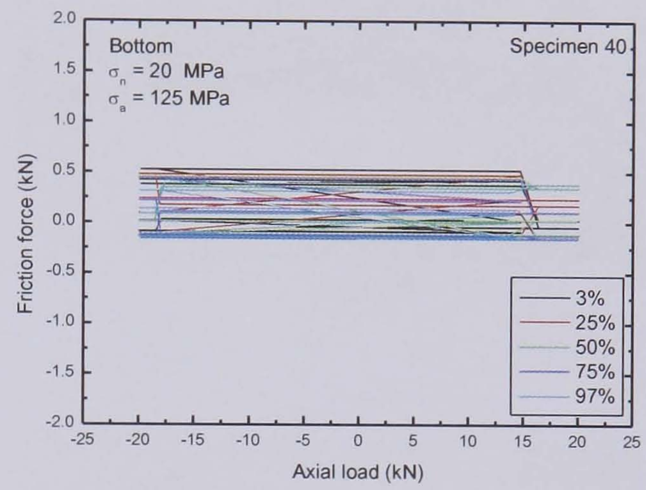

Bottom
σ_n = 100 MPa
σ_a = 100 MPa
Specimen 20
Friction force (kN)
Axial load (kN)
3%
25%
50%
75%
97%

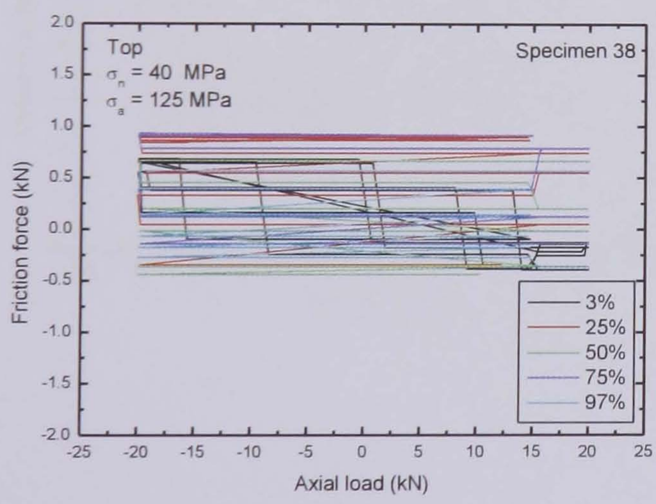
H.3 σ_a = 125 MPa unpeened

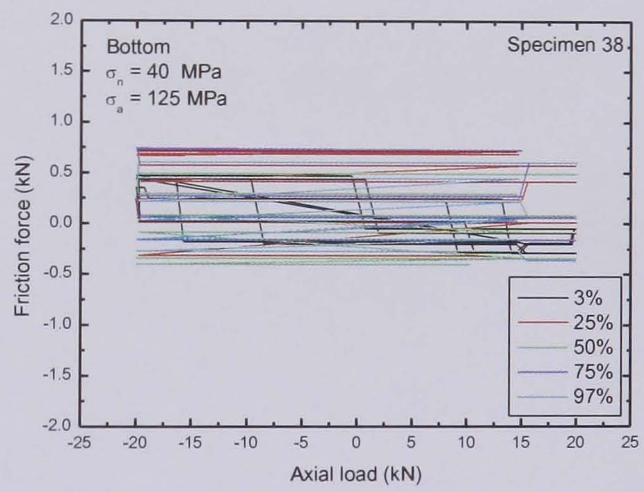


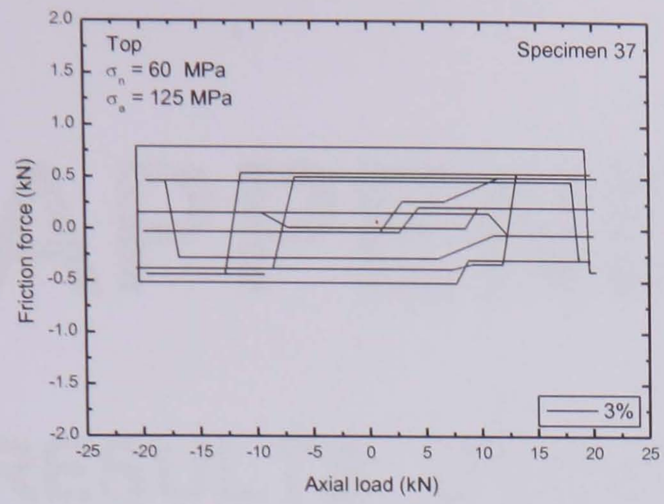


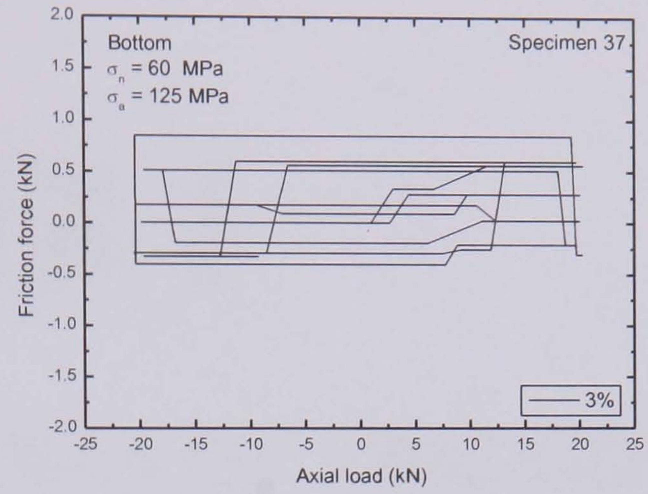


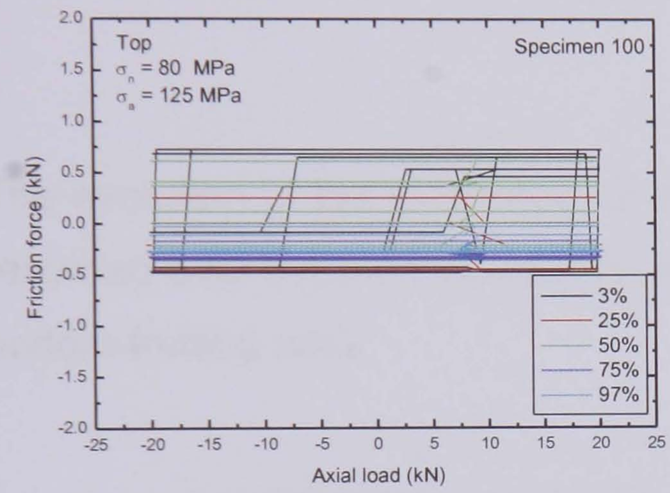


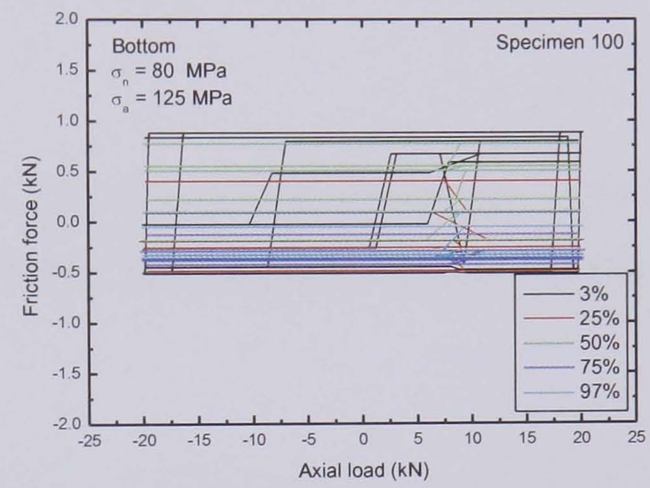


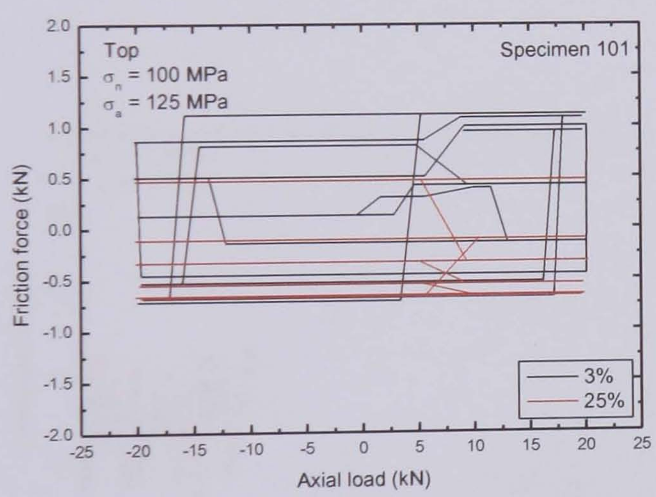


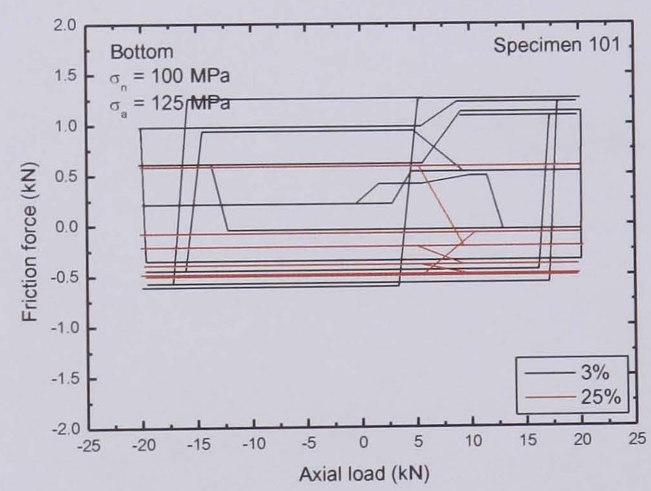

Top
σ_n = 60 MPa
σ_a = 125 MPa
Specimen 37
3%
Friction force (kN)
Axial load (kN)


Bottom
σ_n = 60 MPa
σ_a = 125 MPa
Specimen 37
3%
Friction force (kN)
Axial load (kN)


Top
σ_n = 80 MPa
σ_a = 125 MPa
Specimen 100
3%
25%
50%
75%
97%
Friction force (kN)
Axial load (kN)


Bottom
σ_n = 80 MPa
σ_a = 125 MPa
Specimen 100
3%
25%
50%
75%
97%
Friction force (kN)
Axial load (kN)


Top
σ_n = 100 MPa
σ_a = 125 MPa
Specimen 101
3%
25%
Friction force (kN)
Axial load (kN)

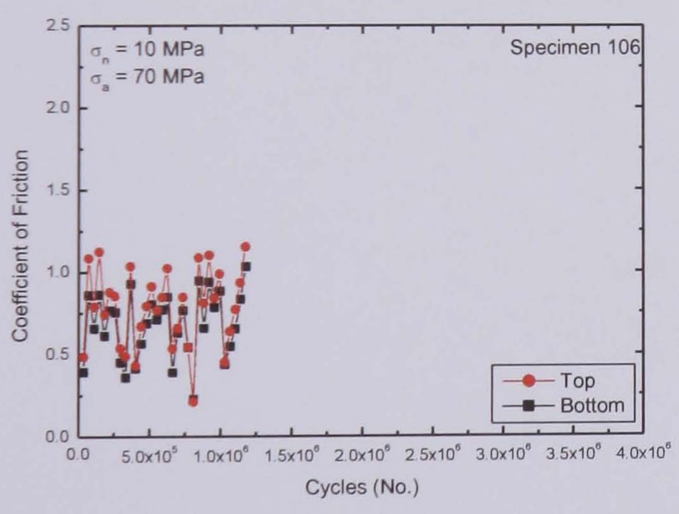

Bottom
σ_n = 100 MPa
σ_a = 125 MPa
Specimen 101
3%
25%
Friction force (kN)
Axial load (kN)

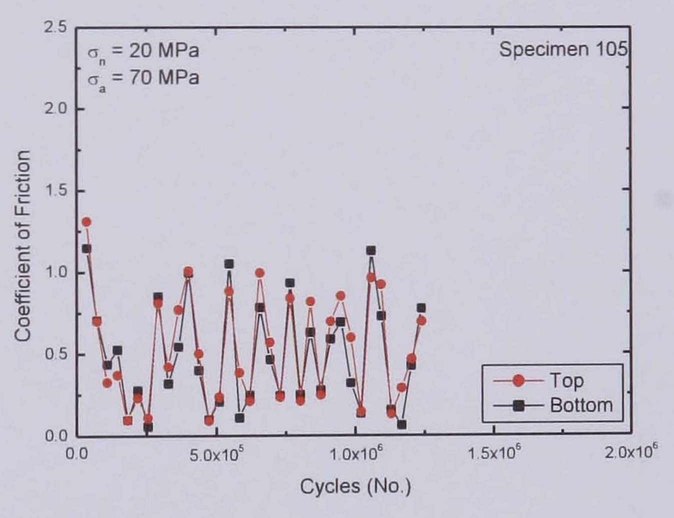
APPENDIX I

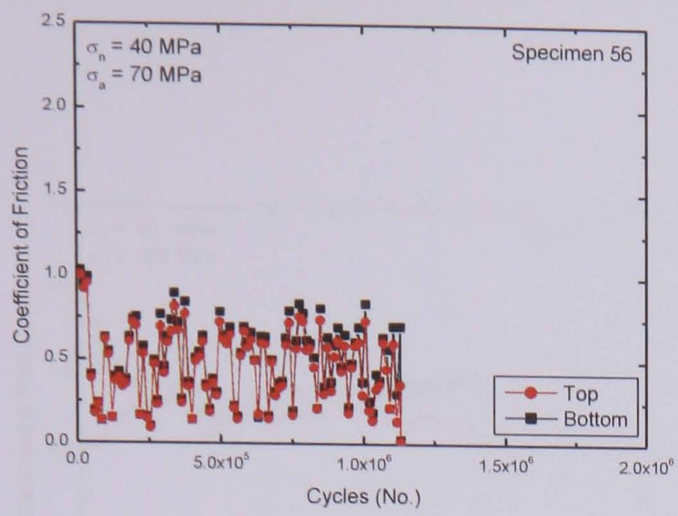
RESULTS: EVOLUTION OF FRICTION COEFFICIENT VALUES

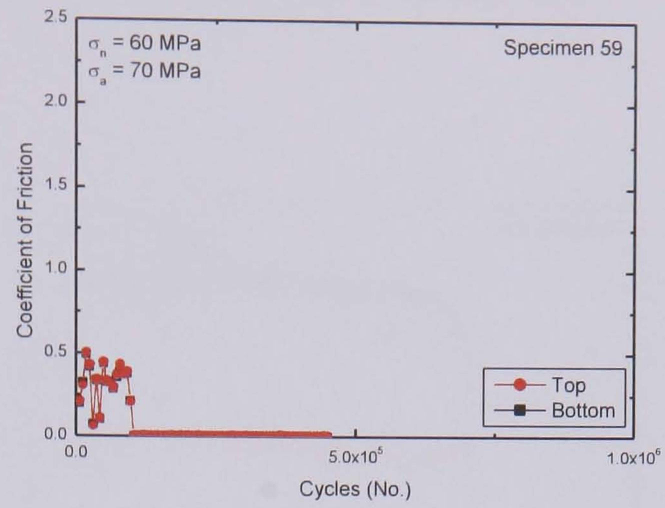
The evolution of the coefficient of friction calculated from the friction force data recorded over the life of every unpeened specimen, traced for both the top and bottom fretting pad.

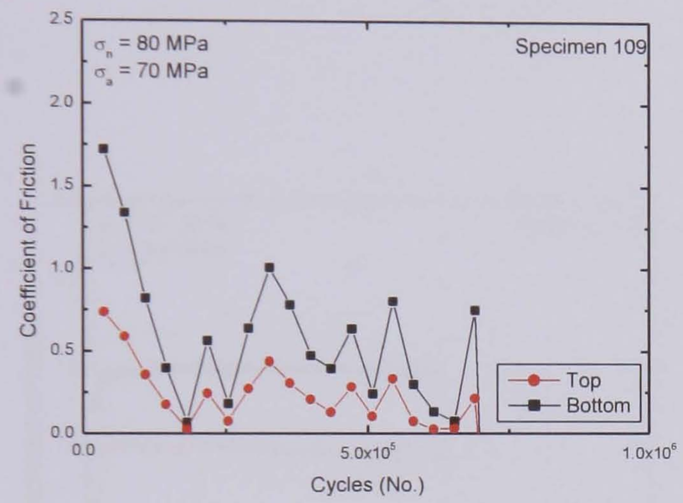
I.1 FRICTION COEFFICIENT: σ_a = 70 MPa unpeened

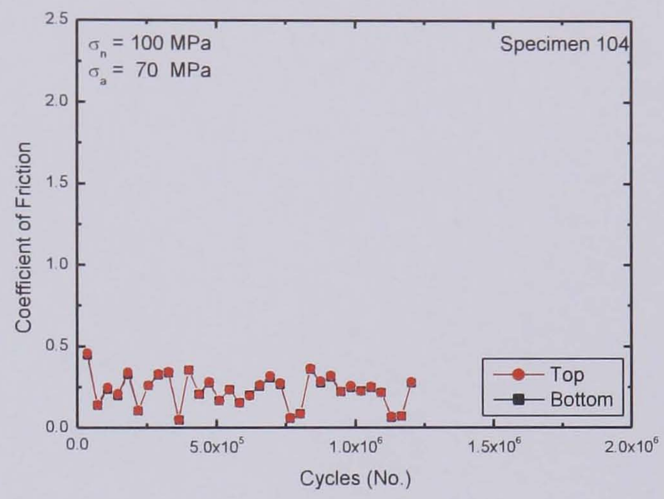




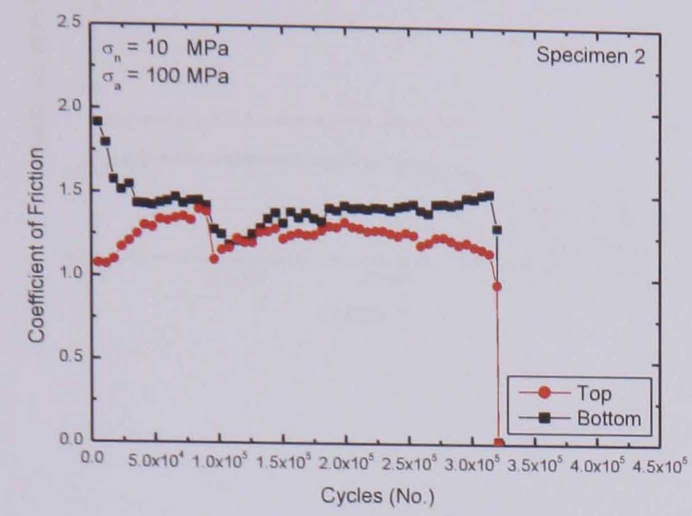

σn = 40 MPa
σa = 70 MPa
Specimen 56
Coefficient of Friction
Cycles (No.)
Top
Bottom
0.0
0.5
1.0
1.5
2.0
2.5
5.0x10^5
1.0x10^6
1.5x10^6
2.0x10^6

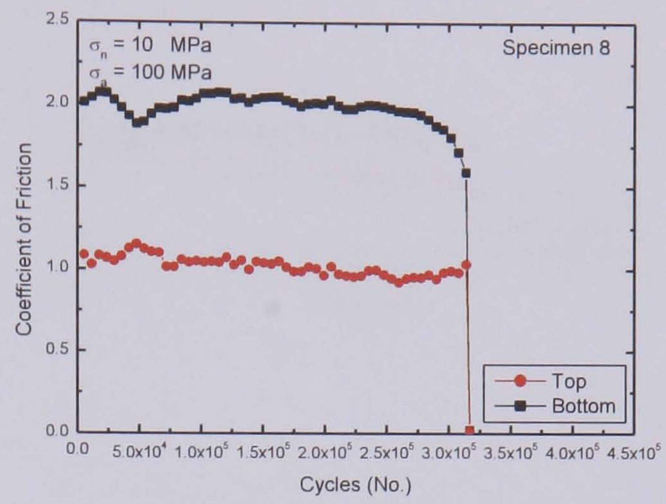

σn = 60 MPa
σa = 70 MPa
Specimen 59
Coefficient of Friction
Cycles (No.)
Top
Bottom
0.0
0.5
1.0
1.5
2.0
2.5
5.0x10^5
1.0x10^6

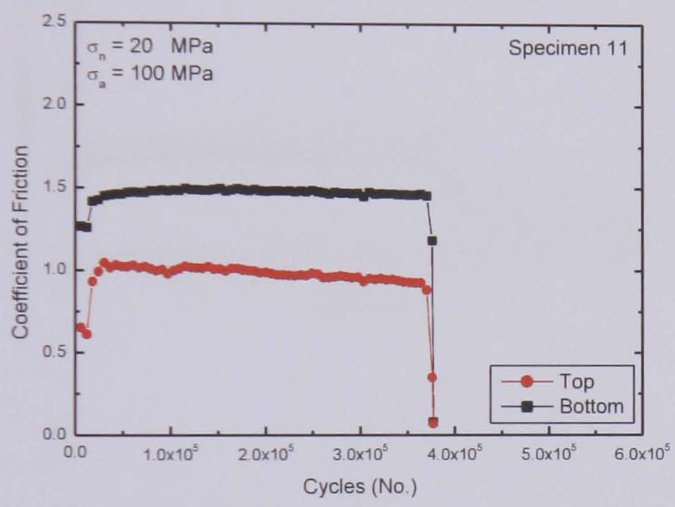

σn = 80 MPa
σa = 70 MPa
Specimen 109
Coefficient of Friction
Cycles (No.)
Top
Bottom
0.0
0.5
1.0
1.5
2.0
2.5
5.0x10^5
1.0x10^6

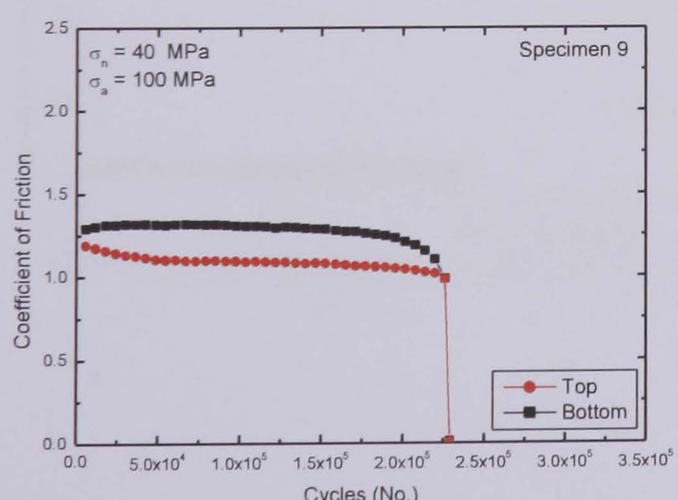

σn = 100 MPa
σa = 70 MPa
Specimen 104
Coefficient of Friction
Cycles (No.)
Top
Bottom
0.0
0.5
1.0
1.5
2.0
2.5
5.0x10^5
1.0x10^6
1.5x10^6
2.0x10^6

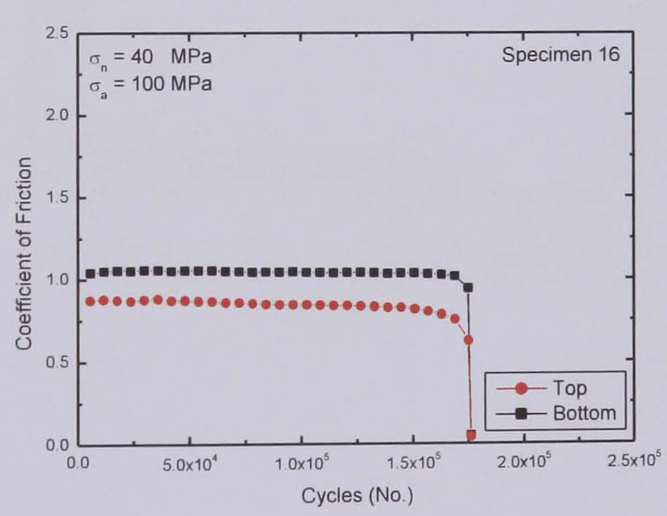
I.2 FRICTION COEFFICIENT: σ_a = 100 MPa unpeened

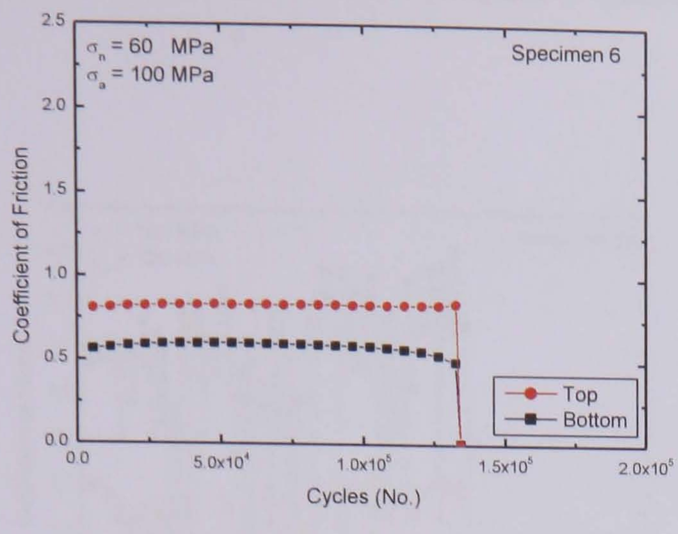


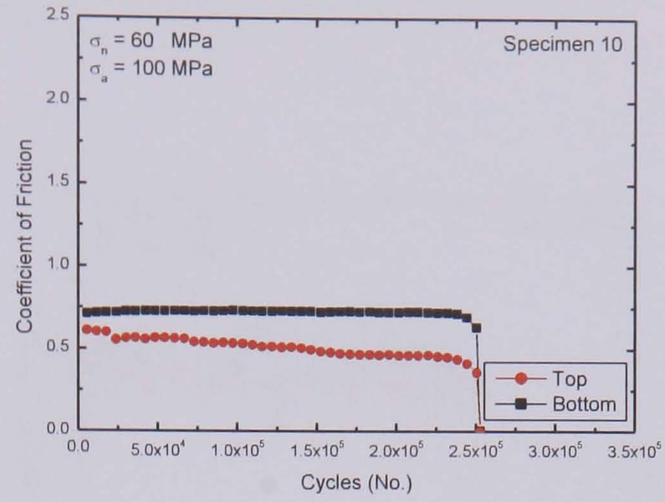


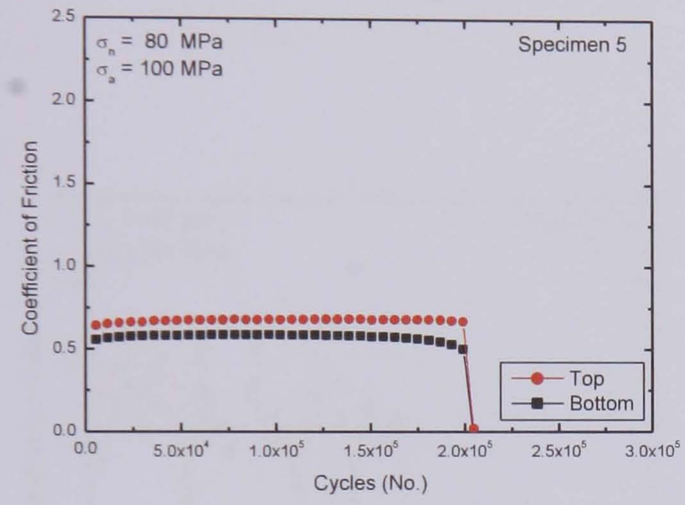


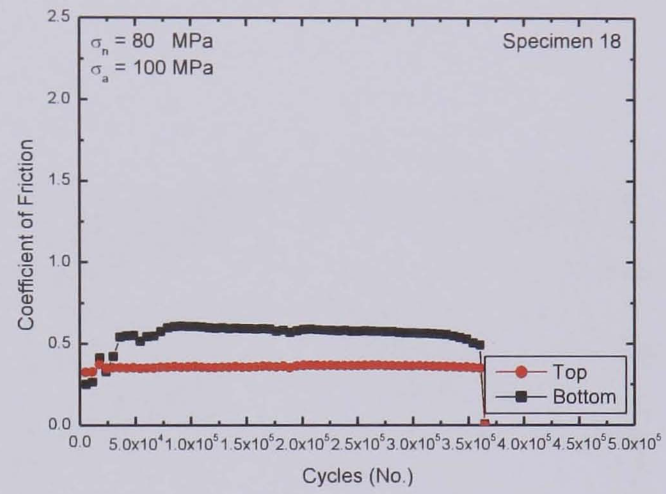


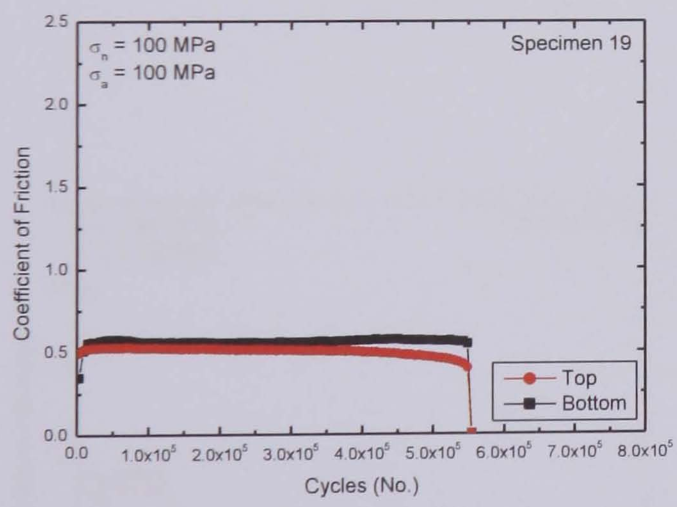


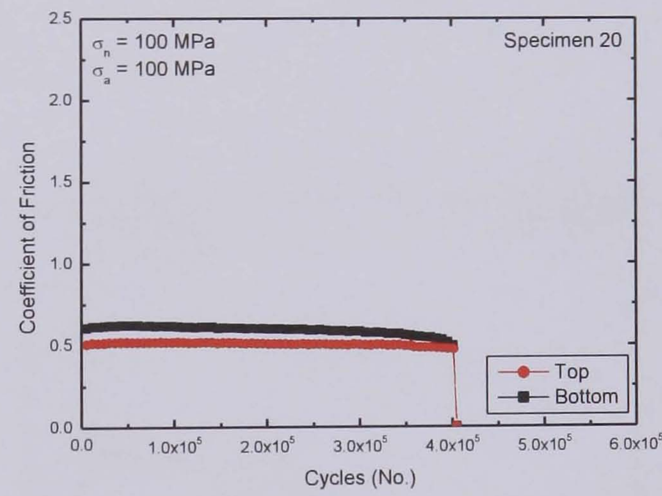

σn = 60 MPa
σa = 100 MPa
Specimen 6
Coefficient of Friction
Cycles (No.)
Top
Bottom


σn = 60 MPa
σa = 100 MPa
Specimen 10
Coefficient of Friction
Cycles (No.)
Top
Bottom

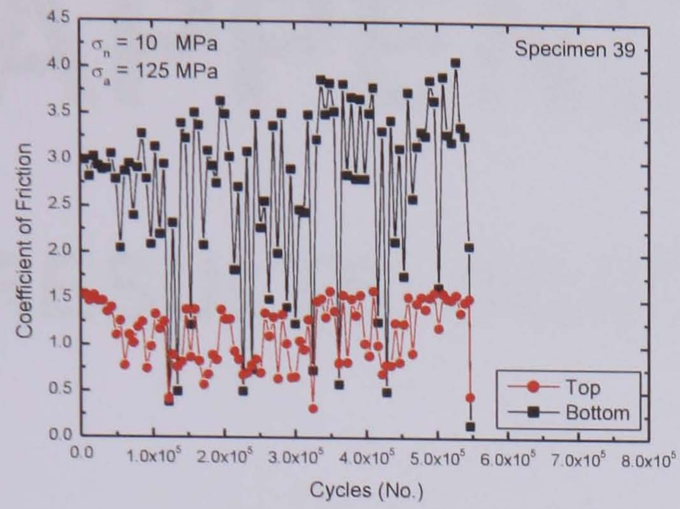

σn = 80 MPa
σa = 100 MPa
Specimen 5
Coefficient of Friction
Cycles (No.)
Top
Bottom

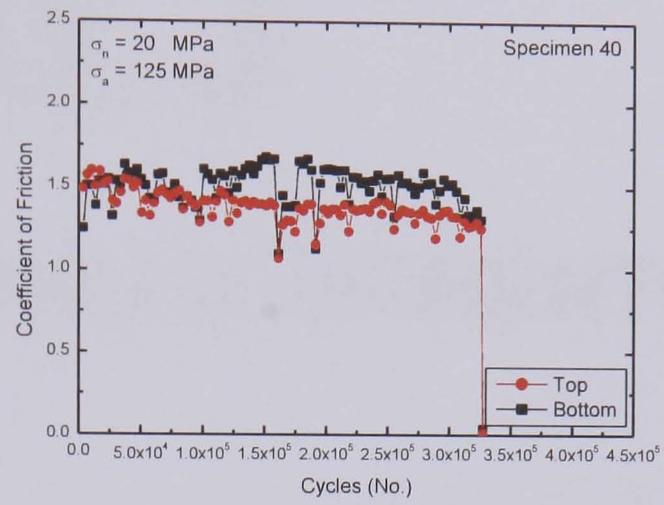

σn = 80 MPa
σa = 100 MPa
Specimen 18
Coefficient of Friction
Cycles (No.)
Top
Bottom

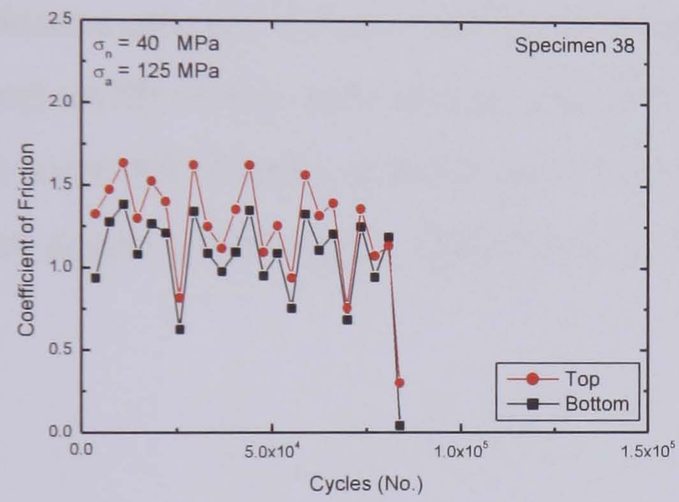

σn = 100 MPa
σa = 100 MPa
Specimen 19
Coefficient of Friction
Cycles (No.)
Top
Bottom

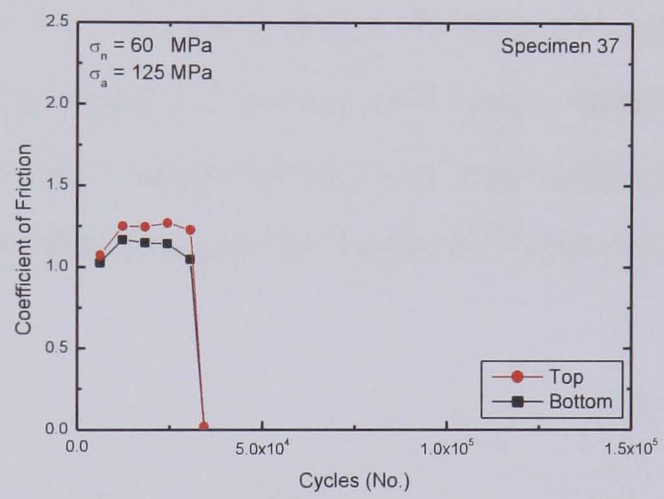

σn = 100 MPa
σa = 100 MPa
Specimen 20
Coefficient of Friction
Cycles (No.)
Top
Bottom

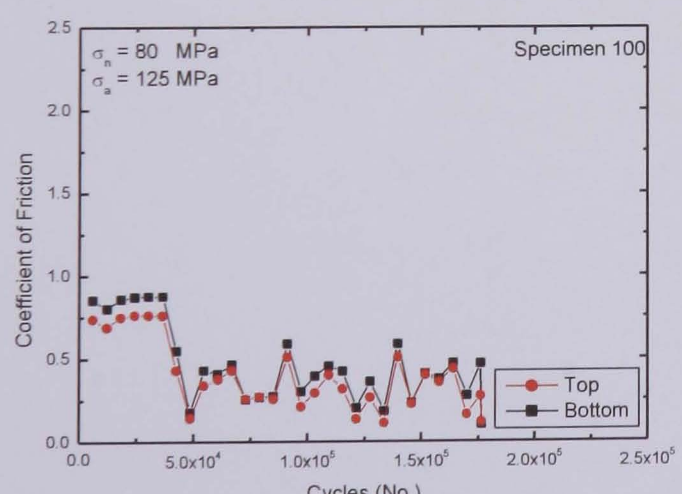
I.3 FRICTION COEFFICIENT: σ_a = 125 MPa unpeened

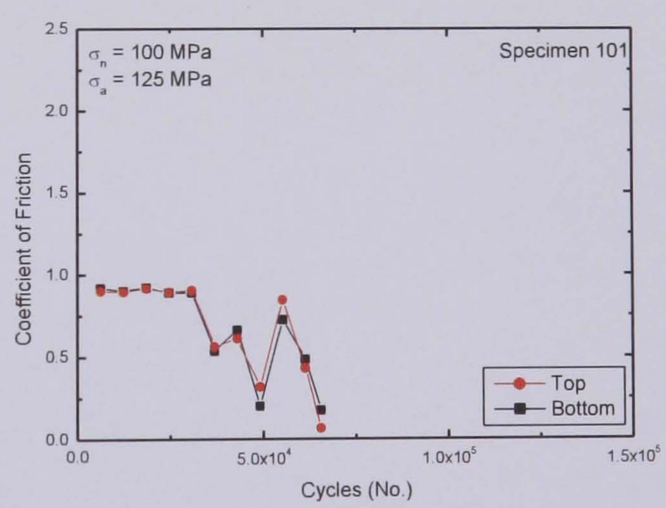












APPENDIX J

RESULTS: SCAR MEASUREMENTS

J.1 UNPEENED: σ_a = 70 MPa

Measurements determined from traces of the fretting scars including: the depth and width of the scar about a base line, the height of peaks that were observed to form either side of the scar, the total peak to valley depth, the total width and the angle of the notch. Definitions of these features can be found in Figure 4.44.

Table J.1a: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to a normal pressure of 10 MPa and an axial stress amplitude of 70 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
43	10%	Bottom	Left	Back	1.887	0.230	6.255	7.905	9.793	0.928	178
43	10%	Bottom	Left	Front	1.464		0.429	-0.234	1.892	1.905	
43	10%	Bottom	Left	Middle	2.895		-1.034	-1.224	1.860	5.598	
43	10%	Bottom	Right	Back	1.269	0.516	0.784	0.326	2.054	1.509	179
43	10%	Bottom	Right	Front	2.304	1.294	0.756	1.071	3.375	4.760	180
43	10%	Bottom	Right	Middle	1.539		-0.844	0.520	2.059	0.622	
43	10%	Top	Left	Back	3.446		-0.762	15.251	18.697	2.915	
43	10%	Top	Left	Front	0.813		0.455	-0.630	1.269	0.412	
43	10%	Top	Left	Middle	2.817	0.206	7.173	1.000	9.991	0.830	177
43	10%	Top	Right	Back	0.993	0.204	0.807	3.625	4.619	0.906	179
43	10%	Top	Right	Front	1.646	1.429	1.930	0.068	3.576	1.847	180
43	10%	Top	Right	Middle	1.542	0.418	1.227	1.539	3.082	0.956	179
49	25%	Bottom	Left	Back	1.560	1.937	1.143	3.948	5.509	2.543	180
49	25%	Bottom	Left	Front	1.683		0.963	-0.793	2.646	0.618	
49	25%	Bottom	Left	Middle	1.936		0.340	-1.110	2.276	1.130	
49	25%	Bottom	Right	Back	1.266	0.826	0.664	0.956	2.222	2.335	180
49	25%	Bottom	Right	Front	1.718		0.595	-0.369	2.314	1.184	
49	25%	Bottom	Right	Middle	1.905		-1.145	6.003	7.907	0.854	
49	25%	Top	Left	Back	1.216	0.456	1.422	0.876	2.638	1.268	179
49	25%	Top	Left	Front	2.048	1.797	1.979	0.459	4.027	2.211	180
49	25%	Top	Left	Middle	2.740	0.208	1.347	0.952	4.087	0.358	177
49	25%	Top	Right	Back	1.864	0.204	1.199	0.807	3.063	1.278	178
49	25%	Top	Right	Front	2.651	0.310	0.783	2.152	4.803	1.168	178
49	25%	Top	Right	Middle	1.616	1.188	1.499	0.736	3.115	1.839	180
51	50%	Bottom	Left	Back	1.900	2.101	0.062	12.802	14.702	2.961	180
51	50%	Bottom	Left	Front	1.479	0.966	0.921	0.881	2.400	5.104	180
51	50%	Bottom	Left	Middle	1.051	0.792	2.110	1.711	3.161	0.944	180
51	50%	Bottom	Right	Back	3.689	0.414	2.134	1.580	5.823	0.716	178
51	50%	Bottom	Right	Front	2.330		-0.272	7.912	10.242	1.507	
51	50%	Bottom	Right	Middle	2.298	1.212	0.323	7.085	9.383	1.651	180
51	50%	Top	Left	Back	2.385	1.238	0.807	0.855	3.240	2.391	180
51	50%	Top	Left	Front	4.449	0.180	1.527	7.848	12.297	1.122	174
51	50%	Top	Left	Middle	9.538	0.320	11.641	9.524	21.179	0.720	173
51	50%	Top	Right	Back	3.704	0.514	1.110	5.598	9.302	1.421	178
51	50%	Top	Right	Front	1.206	0.920	2.449	0.250	3.655	1.533	180
51	50%	Top	Right	Middle	1.840	0.846	0.922	2.317	4.157	1.238	180
66	75%	Bottom	Left	Back	2.477	0.152	0.610	2.033	4.510	1.549	176
66	75%	Bottom	Left	Front	19.374	1.899	11.902	9.159	31.276	2.919	178
66	75%	Bottom	Left	Middle	20.521	1.641	6.450	3.708	26.971	3.141	177
66	75%	Top	Left	Back	2.971	3.019	1.115	-0.500	4.086	3.533	180
66	75%	Top	Left	Front	41.437	0.382	11.282	16.338	57.775	0.924	156
66	75%	Top	Left	Middle	12.316	0.436	12.362	2.075	24.678	1.463	174

	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
Minimum:	0.813	0.152	-1.145	-1.224	1.269	0.358	156
Maximum:	41.437	3.019	12.362	16.338	57.775	5.598	180

Table J.1b: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to a normal pressure of 60 MPa and an axial stress amplitude of 70 MPa.

Specimen	Life proportion	Scar		Trace	Depth	Width	Left peak	Right peak	h	l	θ
(no.)	(%)	T/B	L/R	F/M/B	(µm)	(mm)	(µm)	(µm)	(µm)	(mm)	(°)
69	10%	Bottom	Left	Back	1.044		-0.635	0.542	1.586	1.240	
69	10%	Bottom	Left	Front	1.445	1.867	0.480	-0.268	1.925	1.415	180
69	10%	Bottom	Left	Middle	1.879	0.788	0.530	0.367	2.409	1.769	179
69	10%	Bottom	Right	Back	1.432	1.008	0.694	0.674	2.126	1.601	180
69	10%	Bottom	Right	Front	2.483	0.632	1.403	7.438	9.921	0.974	179
69	10%	Bottom	Right	Middle	1.133	0.466	1.288	0.879	2.421	0.716	179
69	10%	Top	Left	Back	1.998	0.958	1.184	0.420	3.182	1.687	180
69	10%	Top	Left	Front	1.953	0.570	0.358	0.394	2.347	0.738	179
69	10%	Top	Left	Middle	1.351	1.268	1.262	0.300	2.614	2.459	180
69	10%	Top	Right	Back	1.581	1.851	1.710	-0.066	3.290	1.993	180
69	10%	Top	Right	Front	3.117	0.598	1.186	1.736	4.853	2.013	179
69	10%	Top	Right	Middle	1.683	1.010	0.303	0.909	2.592	1.224	180
68	25%	Bottom	Left	Back	1.989		-0.876	0.817	2.806	1.411	
68	25%	Bottom	Left	Front	1.033	1.030	2.562	1.031	3.595	1.713	180
68	25%	Bottom	Left	Middle	1.258	1.471	1.386	1.416	2.674	2.185	180
68	25%	Bottom	Right	Back	1.605	0.896	0.672	1.491	3.096	1.729	180
68	25%	Bottom	Right	Front	1.281	0.798	0.483	1.112	2.394	1.346	180
68	25%	Bottom	Right	Middle	1.235	1.090	0.374	0.726	1.962	2.065	180
68	25%	Top	Left	Back	1.371	0.714	0.989	0.148	2.359	1.493	180
68	25%	Top	Left	Front	2.489	2.261	0.659	1.011	3.500	4.336	180
68	25%	Top	Left	Middle	1.630		-0.902	0.972	2.603	0.700	
68	25%	Top	Right	Back	1.396	1.739	0.806	1.268	2.663	2.543	180
68	25%	Top	Right	Front	0.837		0.692	-0.118	1.529	1.895	
68	25%	Top	Right	Middle	0.814	0.572	0.146	0.967	1.781	1.054	180
53	50%	Bottom	Left	Back	1.977	1.314	0.935	0.367	2.913	2.501	180
53	50%	Bottom	Left	Front	1.551	1.136	1.809	1.028	3.359	1.971	180
53	50%	Bottom	Left	Middle	1.211	1.296	1.765	0.500	2.976	1.557	180
53	50%	Bottom	Right	Back	1.356	0.200	0.843	4.717	6.073	1.485	178
53	50%	Bottom	Right	Front	1.712	0.368	0.351	0.740	2.452	0.460	179
53	50%	Bottom	Right	Middle	1.295		1.496	-0.306	2.791	1.941	
53	50%	Top	Left	Back	0.830		0.705	-0.075	1.536	1.104	
53	50%	Top	Left	Front	1.210	0.536	1.130	2.161	3.371	1.240	179
53	50%	Top	Left	Middle	1.651	0.220	0.961	1.537	3.188	1.427	178
53	50%	Top	Right	Back	1.217	2.043	1.962	0.001	3.179	2.113	180
53	50%	Top	Right	Front	3.832	1.246	2.149	0.413	5.981	1.859	179
53	50%	Top	Right	Middle	3.212	1.709	1.311	-0.134	4.524	1.885	180
63	75%	Bottom	Left	Back	0.949	0.924	0.542	1.185	2.134	1.873	180
63	75%	Bottom	Left	Front	1.279	0.496	1.908	0.682	3.187	2.351	179
63	75%	Bottom	Left	Middle	1.211	0.500	0.842	1.103	2.314	1.755	179
63	75%	Bottom	Right	Back	1.294		0.573	0.039	1.472	1.268	
63	75%	Bottom	Right	Front	1.476		-0.611	1.433	2.909	0.836	
63	75%	Bottom	Right	Middle	1.645	0.272	1.440	1.252	3.085	1.773	179
63	75%	Top	Left	Back	6.462	0.180	3.665	6.969	13.431	0.490	172
63	75%	Top	Left	Front	1.137	1.088	0.414	1.097	2.234	1.443	180
63	75%	Top	Left	Middle	2.220	0.438	0.816	0.910	3.129	1.767	179
63	75%	Top	Right	Back	2.414	1.228	0.757	3.849	6.262	1.869	180
63	75%	Top	Right	Front	1.985		1.066	-0.007	3.051	0.276	
63	75%	Top	Right	Middle	2.602	0.746	1.895	0.452	4.496	1.304	179

	Depth	Width	Left peak	Right peak	h	l	θ
Minimum:	0.814	0.180	-0.902	-0.306	1.472	0.276	172
Maximum:	6.462	2.261	3.665	7.438	13.431	4.336	180

Table J.1c: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024-T351 bridge in contact with an aluminium alloy 2024-T351 specimen subjected to a normal pressure of 100 MPa an axial stress amplitude of 70 MPa.

Specimen (no.)	Life proportion (%)	Scar		Trace	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
		T/B	L/R	F/M/B							
64	10%	Bottom	Left	Back	5.394	0.202	7.330	1.250	12.724	0.340	174
64	10%	Bottom	Left	Front	1.287	0.796	0.909	1.303	2.590	1.296	180
64	10%	Bottom	Left	Middle	1.783	1.166	0.961	0.244	2.744	1.981	180
64	10%	Bottom	Right	Back	2.806	0.108	2.188	2.235	5.041	0.466	174
64	10%	Bottom	Right	Front	1.840	1.092	1.905	1.319	3.745	1.687	180
64	10%	Bottom	Right	Middle	1.021	0.978	0.518	0.539	1.560	1.871	180
64	10%	Top	Left	Back	1.019	0.276	0.440	0.359	1.459	1.607	179
64	10%	Top	Left	Front	0.996	1.813	0.364	0.570	1.566	4.216	180
64	10%	Top	Left	Middle	1.924		1.760	-0.335	3.684	1.188	
64	10%	Top	Right	Back	1.100	1.595	1.395	0.539	2.496	2.313	180
64	10%	Top	Right	Front	2.040	1.398	1.311	0.679	3.351	2.301	180
64	10%	Top	Right	Middle	1.450	0.330	1.417	0.493	2.867	1.340	179
61	25%	Bottom	Left	Back	1.806		-0.978	1.339	3.145	1.421	
61	25%	Bottom	Left	Front	1.642	1.368	0.839	0.722	2.481	1.897	180
61	25%	Bottom	Left	Middle	1.667	0.760	1.400	0.865	3.067	1.407	179
61	25%	Bottom	Right	Back	2.018		1.198	-0.001	3.216	1.398	
61	25%	Bottom	Right	Front	1.275		0.729	-0.328	2.005	1.372	
61	25%	Bottom	Right	Middle	1.248	0.588	0.618	2.102	3.350	4.336	180
61	25%	Top	Left	Back	2.969	0.610	0.043	1.743	4.712	1.372	179
61	25%	Top	Left	Front	1.208	1.290	0.331	0.588	1.796	4.011	180
61	25%	Top	Left	Middle	1.426	0.528	0.825	1.363	2.789	1.086	179
61	25%	Top	Right	Back	1.397	0.466	0.545	1.289	2.686	1.084	179
61	25%	Top	Right	Front	1.526	0.412	1.662	1.803	3.329	1.132	179
61	25%	Top	Right	Middle	1.652		-0.932	1.082	2.734	1.094	
70	50%	Bottom	Left	Back	1.419	0.668	0.958	1.483	2.902	1.587	180
70	50%	Bottom	Left	Front	1.328	1.471	0.922	0.220	2.251	3.579	180
70	50%	Bottom	Left	Middle	1.461		1.384	-0.280	2.844	1.188	
70	50%	Bottom	Right	Back	1.065	1.172	0.551	0.710	1.775	2.219	180
70	50%	Bottom	Right	Front	3.969	1.362	2.182	2.033	6.151	2.041	179
70	50%	Bottom	Right	Middle	1.765	0.426	1.326	2.192	3.957	1.236	179
70	50%	Top	Left	Back	2.174	1.368	0.762	0.399	2.936	3.551	180
70	50%	Top	Left	Front	1.564	1.575	0.114	1.083	2.646	1.723	180
70	50%	Top	Left	Middle	1.202		-0.645	0.694	1.896	1.298	
70	50%	Top	Right	Back	1.803	1.332	0.948	0.552	2.751	4.404	180
70	50%	Top	Right	Front	1.070	0.382	0.877	0.434	1.947	1.877	179
70	50%	Top	Right	Middle	2.208	1.020	0.938	0.348	3.146	1.162	180
50	75%	Bottom	Left	Back	1.760	0.948	1.042	0.196	2.802	1.775	180
50	75%	Bottom	Left	Front	1.775	1.128	0.854	0.629	2.629	2.125	180
50	75%	Bottom	Left	Middle	1.690	0.706	0.459	0.215	2.149	0.834	179
50	75%	Bottom	Right	Back	1.342	1.002	0.931	0.455	2.273	1.739	180
50	75%	Bottom	Right	Front	1.051	0.668	0.626	0.421	1.678	1.132	180
50	75%	Bottom	Right	Middle	0.990	0.686	0.625	1.635	2.626	1.238	180
50	75%	Top	Left	Back	1.430	0.652	0.365	0.055	1.794	1.497	179
50	75%	Top	Left	Front	1.215	0.966	0.426	0.058	1.641	1.431	180
50	75%	Top	Left	Middle	1.974	0.656	1.240	0.344	3.214	1.843	179
50	75%	Top	Right	Back	2.047	0.420	1.384	0.172	3.431	0.828	179
50	75%	Top	Right	Front	2.517	1.561	6.797	-0.101	9.315	0.750	180
50	75%	Top	Right	Middle	1.196	1.651	0.784	0.599	1.980	1.907	180

	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
Minimum:	0.990	0.108	-0.978	-0.335	1.459	0.340	174
Maximum:	5.394	1.813	7.330	2.235	12.724	4.404	180

J.2 UNPEENED: σ_a = 100 MPa

Table J.2a: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024-T351 bridge in contact with an aluminium alloy 2024-T351 specimen subjected to a normal pressure of 10 MPa and an axial stress amplitude of 100 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
26	10%	Bottom	Left	Back	0.866		-0.265	0.324	1.190	0.954	
26	10%	Bottom	Left	Front	2.401	1.048	2.736	0.024	5.137	1.396	179
26	10%	Bottom	Left	Middle	2.708	0.216	1.730	0.641	4.439	1.485	177
26	10%	Bottom	Right	Back	1.506	1.571	0.776	0.957	2.462	2.277	180
26	10%	Bottom	Right	Front	2.182	1.288	1.210	1.932	4.114	1.951	180
26	10%	Bottom	Right	Middle	1.378	0.698	0.635	2.826	4.205	4.852	180
26	10%	Top	Left	Back	1.531		1.859	-0.131	3.390	1.443	
26	10%	Top	Left	Front	1.497	1.719	0.795	0.929	2.426	3.875	180
26	10%	Top	Left	Middle	2.024	1.178	1.866	0.285	3.889	1.631	180
26	10%	Top	Right	Back	1.171	1.018	1.055	0.558	2.227	2.319	180
26	10%	Top	Right	Front	2.164		-1.218	0.821	2.985	1.499	
26	10%	Top	Right	Middle	3.003	0.182	4.019	1.089	7.022	0.726	176
23	25%	Bottom	Left	Back	0.864	0.882	0.601	0.161	1.465	3.825	180
23	25%	Bottom	Left	Front	7.907	0.814	1.788	3.593	11.500	1.114	178
23	25%	Bottom	Left	Middle	2.084	1.012	0.268	0.368	2.451	1.382	180
23	25%	Bottom	Right	Back	1.047	0.426	1.046	0.796	2.093	0.844	179
23	25%	Bottom	Right	Front	2.240	0.806	0.637	2.775	5.015	2.067	179
23	25%	Bottom	Right	Middle	1.308	1.216	0.579	0.551	1.887	2.029	180
23	25%	Top	Left	Back	1.457	0.556	7.458	0.562	8.915	0.734	179
23	25%	Top	Left	Front	1.848		5.206	-0.079	7.054	2.177	
23	25%	Top	Left	Middle	2.316	0.892	0.935	4.638	6.955	1.533	179
23	25%	Top	Right	Back	2.656		1.679	-0.205	4.335	1.987	
23	25%	Top	Right	Front	9.369	0.398	1.497	10.482	19.851	0.558	175
23	25%	Top	Right	Middle	3.045	0.100	4.782	13.351	16.396	0.310	173
24	50%	Bottom	Left	Back	3.010	1.002	5.318	2.808	8.329	1.663	179
24	50%	Bottom	Left	Front	5.407	0.852	2.018	7.497	12.904	1.747	179
24	50%	Bottom	Left	Middle	3.490	1.368	1.979	0.440	5.470	3.265	179
24	50%	Bottom	Right	Back	0.919	0.552	0.527	0.938	1.857	1.411	180
24	50%	Bottom	Right	Front	4.755	0.676	2.105	11.749	16.504	0.922	178
24	50%	Bottom	Right	Middle	2.261	0.562	8.087	0.131	10.347	1.593	179
24	50%	Top	Left	Back	1.790	0.538	2.096	1.947	3.886	0.904	179
24	50%	Top	Left	Front	1.793	1.258	1.511	2.853	4.647	2.325	180
24	50%	Top	Left	Middle	13.232	0.576	7.445	1.892	20.677	1.435	175
24	50%	Top	Right	Back	1.486	0.300	0.612	1.785	3.271	1.052	179
24	50%	Top	Right	Front	0.947	0.242	0.037	1.727	2.674	0.462	179
24	50%	Top	Right	Middle	2.715	1.098	0.966	3.084	5.799	2.393	179
25	75%	Bottom	Left	Back	1.933		-0.139	1.369	3.302	1.314	
25	75%	Bottom	Left	Front	5.760	1.078	2.596	2.239	8.357	1.535	179
25	75%	Bottom	Left	Middle	17.464	1.220	7.665	2.872	25.128	1.380	177
25	75%	Bottom	Right	Back	5.071	0.600	4.773	1.376	9.844	1.555	178
25	75%	Bottom	Right	Front	7.376	1.236	2.821	5.816	13.193	1.815	179
25	75%	Bottom	Right	Middle	8.320	1.068	17.436	1.699	25.756	1.493	178
25	75%	Top	Left	Back	1.503	0.560	0.830	3.277	4.780	1.148	179
25	75%	Top	Left	Front	14.538	0.248	5.641	8.704	23.242	1.050	167
25	75%	Top	Left	Middle	10.791	0.194	5.196	14.171	24.961	1.370	167
25	75%	Top	Right	Back	1.465	0.832	0.719	0.455	2.184	1.120	180
25	75%	Top	Right	Front	3.012		15.695	-1.737	18.707	1.749	
25	75%	Top	Right	Middle	1.917	0.858	1.179	0.523	3.097	1.122	179

	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
Minimum:	0.864	0.100	-1.218	-1.737	1.190	0.310	167
Maximum:	17.464	1.719	17.436	14.171	25.756	4.852	180

Table J.2b: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to a normal pressure of 40 MPa and an axial stress amplitude of 100 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
31	10%	Bottom	Left	Back	4.664	0.358	1.083	5.356	10.020	0.618	177
31	10%	Bottom	Left	Front	3.500	1.120	1.616	3.396	6.896	1.621	179
31	10%	Bottom	Left	Middle	4.605	0.158	0.694	2.000	6.605	0.896	173
31	10%	Bottom	Right	Back	2.559	0.126	1.273	5.030	7.588	0.826	175
31	10%	Bottom	Right	Front	1.421	0.356	0.678	0.553	2.099	1.465	179
31	10%	Bottom	Right	Middle	1.557	0.428	0.815	0.786	2.371	1.172	179
31	10%	Top	Left	Back	2.960	2.617	1.884	-0.035	4.844	1.443	180
31	10%	Top	Left	Front	2.582	0.282	6.581	1.183	9.163	0.422	178
31	10%	Top	Left	Middle	1.654	0.274	0.072	1.042	2.696	1.441	179
31	10%	Top	Right	Back	1.844	1.673	0.304	2.320	4.165	2.525	180
31	10%	Top	Right	Front	1.459	1.469	4.370	0.017	5.829	2.375	180
31	10%	Top	Right	Middle	1.019		-0.456	0.804	1.823	1.070	
28	25%	Bottom	Left	Back	3.182		5.409	-0.869	8.591	1.162	
28	25%	Bottom	Left	Front	2.403	2.079	2.005	-0.110	4.408	1.503	180
28	25%	Bottom	Left	Middle	2.104	0.174	0.286	1.923	4.027	1.403	177
28	25%	Bottom	Right	Back	2.694	1.204	4.462	1.966	7.156	1.755	179
28	25%	Bottom	Right	Front	4.391	0.270	2.118	3.239	7.630	0.964	176
28	25%	Bottom	Right	Middle	1.225	1.154	1.039	1.034	2.263	1.603	180
28	25%	Top	Left	Back	4.837	0.950	3.260	0.006	8.097	1.681	179
28	25%	Top	Left	Front	1.931	0.438	1.205	0.503	3.136	0.880	179
28	25%	Top	Left	Middle	7.940	1.102	2.147	9.806	17.746	1.621	178
28	25%	Top	Right	Back	1.455	0.740	0.736	1.207	2.662	2.109	180
28	25%	Top	Right	Front	2.042	1.561	0.721	1.248	3.290	4.093	180
28	25%	Top	Right	Middle	10.597	0.370	3.003	5.424	16.020	1.252	173
29	50%	Bottom	Left	Back	4.817	0.580	3.546	6.997	11.813	1.178	178
29	50%	Bottom	Left	Front	1.827	0.208	0.604	2.290	4.117	0.392	178
29	50%	Bottom	Left	Middle	4.499	0.148	7.920	8.924	13.423	0.938	173
29	50%	Bottom	Right	Back	10.948	0.524	5.129	1.398	16.077	1.034	175
29	50%	Bottom	Right	Front	1.330	1.118	0.570	2.068	3.398	2.149	180
29	50%	Bottom	Right	Middle	2.717	0.170	5.014	0.858	7.731	0.318	176
29	50%	Top	Left	Back	2.294	0.684	2.528	0.969	4.822	1.455	179
29	50%	Top	Left	Front	1.385	0.768	0.430	1.036	2.421	1.531	180
29	50%	Top	Left	Middle	1.676	1.030	1.973	0.992	3.649	1.549	180
29	50%	Top	Right	Back	1.847	1.581	0.146	0.416	2.263	1.901	180
29	50%	Top	Right	Front	1.382	1.425	3.516	0.500	4.898	1.813	180
29	50%	Top	Right	Middle	2.848	0.394	6.305	6.164	9.152	0.570	178
30	75%	Bottom	Left	Back	2.471	1.214	0.671	1.030	3.501	1.701	180
30	75%	Bottom	Left	Front	3.584	0.292	2.011	2.246	5.830	0.428	177
30	75%	Bottom	Left	Middle	2.698		13.665	-0.501	16.362	1.262	
30	75%	Bottom	Right	Back	1.058	0.670	0.981	1.305	2.363	1.831	180
30	75%	Bottom	Right	Front	2.548	1.487	-0.167	2.544	5.092	3.977	180
30	75%	Bottom	Right	Middle	1.294	0.848	0.355	0.405	1.699	1.138	180
30	75%	Top	Left	Back	6.181	0.532	3.216	0.256	9.396	1.162	177
30	75%	Top	Left	Front	2.961	0.140	1.559	4.107	7.069	0.456	175
30	75%	Top	Left	Middle	2.388	1.947	1.804	0.257	4.192	2.397	180
30	75%	Top	Right	Back	2.093	2.113	1.317	0.028	3.410	2.275	180
30	75%	Top	Right	Front	1.296	2.473	0.788	0.491	2.083	4.087	180
30	75%	Top	Right	Middle	1.175	0.462	0.747	0.455	1.922	1.633	179
Minimum:					1.019	0.126	-0.456	-0.869	1.699	0.318	173
Maximum:					10.948	2.617	13.665	9.806	17.746	4.093	180

Table J.2c: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to a normal pressure of 100 MPa an axial stress amplitude of 100 MPa.

Specimen (no.)	Life proportion (%)	Scar		Trace	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
		T/B	L/R	F/M/B							
32	10%	Bottom	Left	Back	1.470		3.398	-0.268	4.868	1.801	
32	10%	Bottom	Left	Front	3.655	1.014	5.535	7.886	11.541	1.338	179
32	10%	Bottom	Left	Middle	3.264		1.015	-3.078	4.278	0.148	
32	10%	Bottom	Right	Back	1.478	0.452	0.271	4.116	5.594	1.419	179
32	10%	Bottom	Right	Front	1.246	1.010	1.720	0.191	2.966	1.903	180
32	10%	Bottom	Right	Middle	2.507	0.946	3.807	1.072	6.314	1.286	179
32	10%	Top	Left	Back	1.649	0.230	0.754	2.516	4.165	0.986	178
32	10%	Top	Left	Front	1.106	0.260	1.374	1.036	2.480	1.571	179
32	10%	Top	Left	Middle	2.285	0.848	1.527	1.623	3.908	1.439	179
32	10%	Top	Right	Back	1.869	1.182	0.581	5.392	7.261	3.491	180
32	10%	Top	Right	Front	2.019	0.918	4.830	2.799	6.849	1.338	179
32	10%	Top	Right	Middle	1.820	0.562	1.846	0.213	3.666	0.668	179
33	25%	Bottom	Left	Back	1.291	0.642	1.461	0.468	2.752	0.792	180
33	25%	Bottom	Left	Front	5.336	1.148	3.130	2.766	8.466	1.346	179
33	25%	Bottom	Left	Middle	3.264	1.026	14.774	5.014	18.038	1.284	179
33	25%	Bottom	Right	Back	1.125	0.792	0.763	0.869	1.994	1.302	180
33	25%	Bottom	Right	Front	2.083	0.848	1.442	2.535	4.618	1.338	179
33	25%	Bottom	Right	Middle	5.747	0.744	9.321	5.962	15.068	1.160	178
33	25%	Top	Left	Back	1.824		-0.917	1.474	3.298	1.374	
33	25%	Top	Left	Front	2.142	0.742	1.229	4.449	6.592	2.243	179
33	25%	Top	Left	Middle	1.531	0.152	1.098	2.814	4.345	1.212	178
33	25%	Top	Right	Back	2.297		1.337	-0.555	3.634	1.619	
33	25%	Top	Right	Front	3.720	0.262	1.539	1.206	5.259	1.082	177
33	25%	Top	Right	Middle	7.015	0.218	1.703	9.122	16.137	0.694	173
34	50%	Bottom	Left	Back	1.431	1.086	0.928	0.756	2.359	1.755	180
34	50%	Bottom	Left	Front	2.433	0.854	1.209	0.687	3.643	1.903	179
34	50%	Bottom	Left	Middle	0.951		-0.426	1.441	2.392	1.557	
34	50%	Bottom	Right	Back	5.407	0.174	2.625	15.015	20.422	0.856	173
34	50%	Bottom	Right	Front	1.396		0.580	-0.485	1.976	1.298	
34	50%	Bottom	Right	Middle	1.888	2.001	1.113	-0.357	3.001	1.861	180
34	50%	Top	Left	Back	0.901	0.548	0.344	0.618	1.519	1.386	180
34	50%	Top	Left	Front	2.049		-0.208	1.866	3.915	1.192	
34	50%	Top	Left	Middle	1.709		6.219	-0.374	7.928	1.701	
34	50%	Top	Right	Back	1.873	0.374	0.092	0.335	2.208	0.454	179
34	50%	Top	Right	Front	6.117	0.174	3.629	0.904	9.746	1.052	172
34	50%	Top	Right	Middle	1.354		-0.465	0.423	1.777	1.264	
35	75%	Bottom	Left	Back	5.189	1.597	0.798	6.171	11.361	1.983	179
35	75%	Bottom	Left	Front	4.267	1.507	1.786	6.497	10.764	2.217	179
35	75%	Bottom	Left	Middle	5.310	1.455	1.204	4.966	10.275	2.079	179
35	75%	Bottom	Right	Back	1.703	0.550	1.905	0.712	3.608	0.978	179
35	75%	Bottom	Right	Front	2.817	1.070	1.528	4.134	6.951	2.331	179
35	75%	Bottom	Right	Middle	1.410		0.051	-0.367	1.461	5.598	
35	75%	Top	Left	Back	2.400	1.166	0.867	1.433	3.833	2.215	180
35	75%	Top	Left	Front	3.236	1.691	-0.056	4.354	7.591	1.246	180
35	75%	Top	Left	Middle	2.185		-1.216	1.549	3.734	0.802	
35	75%	Top	Right	Back	1.427	0.590	0.311	0.413	1.839	1.903	179
35	75%	Top	Right	Front	2.164	0.644	4.790	0.552	6.954	1.072	179
35	75%	Top	Right	Middle	3.659	0.682	4.514	0.327	8.173	0.812	179
Minimum:					0.901	0.152	-1.216	-3.078	1.461	0.148	172
Maximum:					7.015	2.001	14.774	15.015	20.422	5.598	180

J.3 UNPEENED: σ_a = 125 MPa

Table J.3a: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to a normal pressure of 10 MPa and an axial stress amplitude of 125 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
42	10%	Bottom	Left	Back	1.203	0.514	0.547	0.978	2.180	1.575	179
42	10%	Bottom	Left	Front	4.513	0.530	2.589	4.121	8.634	1.511	178
42	10%	Bottom	Left	Middle	23.630	0.372	7.930	6.843	31.560	0.678	166
42	10%	Bottom	Right	Back	1.404	1.026	0.456	0.338	1.859	4.802	180
42	10%	Bottom	Right	Front	3.738	3.361	1.813	-1.224	5.551	3.063	180
42	10%	Bottom	Right	Middle	1.604	0.716	1.351	0.980	2.955	2.199	179
42	10%	Top	Left	Back	2.037	1.565	1.532	4.349	6.386	2.325	180
42	10%	Top	Left	Front	2.701	2.189	0.181	9.910	12.612	2.891	180
42	10%	Top	Left	Middle	15.770	0.494	6.452	3.071	22.222	0.934	173
42	10%	Top	Right	Back	1.010	0.414	0.816	2.378	3.388	1.895	179
42	10%	Top	Right	Front	1.479	1.605	1.286	-0.108	2.765	1.511	180
42	10%	Top	Right	Middle	0.755	1.036	0.529	0.106	1.284	2.445	180
45	25%	Bottom	Left	Back	1.419	0.366	0.472	2.127	3.546	0.586	179
45	25%	Bottom	Left	Front	2.282	1.731	5.399	0.896	7.681	1.947	180
45	25%	Bottom	Left	Middle	13.482	0.648	5.541	5.985	19.466	0.896	175
45	25%	Bottom	Right	Back	2.598	0.476	1.316	6.097	8.695	1.318	179
45	25%	Bottom	Right	Front	2.202		-0.007	-1.211	2.195	1.226	
45	25%	Bottom	Right	Middle	1.165	0.574	1.122	0.110	2.287	1.400	180
45	25%	Top	Left	Back	2.572		2.010	-1.205	4.582	1.238	
45	25%	Top	Left	Front	4.781		26.787	-2.128	31.568	1.749	
45	25%	Top	Left	Middle	15.280	0.742	12.218	2.034	27.498	0.958	175
45	25%	Top	Right	Back	1.577	0.892	0.952	1.564	3.141	2.011	180
45	25%	Top	Right	Front	1.887		0.256	-0.462	2.143	0.682	
45	25%	Top	Right	Middle	1.003	1.667	0.306	0.500	1.504	3.819	180
46	50%	Bottom	Left	Back	3.545	0.434	1.265	7.415	10.960	1.116	178
46	50%	Bottom	Left	Front	1.020	0.868	0.578	0.810	1.830	2.199	180
46	50%	Bottom	Left	Middle	6.104	0.336	5.239	6.859	12.963	1.004	176
46	50%	Bottom	Right	Back	8.995	1.813	0.870	5.645	14.640	2.901	179
46	50%	Bottom	Right	Front	0.761	0.522	0.895	0.283	1.656	1.803	180
46	50%	Bottom	Right	Middle	1.053	1.032	0.617	0.071	1.670	2.385	180
46	50%	Top	Left	Back	1.266		0.688	-0.569	1.953	1.036	
46	50%	Top	Left	Front	1.580	0.438	0.291	0.707	2.287	1.487	179
46	50%	Top	Left	Middle	0.966	0.494	0.363	0.556	1.522	1.587	180
46	50%	Top	Right	Back	1.276	1.645	1.119	4.523	5.799	2.447	180
46	50%	Top	Right	Front	1.068	0.554	0.624	2.371	3.438	1.403	180
46	50%	Top	Right	Middle	1.793	0.350	0.725	1.856	3.648	1.555	179
48	75%	Bottom	Left	Back	3.269	0.748	1.164	4.265	7.534	1.058	179
48	75%	Bottom	Left	Front	10.515	0.400	1.243	14.455	24.970	0.750	174
48	75%	Bottom	Left	Middle	9.323	0.534	1.709	7.160	16.483	1.032	176
48	75%	Bottom	Right	Back	1.886	1.228	0.509	0.339	2.395	3.037	180
48	75%	Bottom	Right	Front	4.698		-0.619	-2.045	4.079	5.598	
48	75%	Bottom	Right	Middle	2.466	0.672	1.004	8.406	10.872	0.854	179
48	75%	Top	Left	Back	2.110	0.242	4.567	3.203	6.677	0.642	178
48	75%	Top	Left	Front	3.521		-1.840	1.588	5.108	1.555	
48	75%	Top	Left	Middle	2.877	1.376	5.244	0.118	8.120	2.277	180
48	75%	Top	Right	Back	3.322	1.925	-0.016	4.525	7.847	0.990	180
48	75%	Top	Right	Front	5.092		-1.751	-2.285	3.342	5.598	
48	75%	Top	Right	Middle	3.157	0.098	4.395	4.338	7.552	0.232	173

	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
Minimum:	0.755	0.098	-1.840	-2.285	1.284	0.232	166
Maximum:	23.630	3.361	26.787	14.455	31.568	5.598	180

Table J.3b: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to a normal pressure of 60 MPa and an axial stress amplitude of 125 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
67	10%	Bottom	Left	Back	3.038		2.344	-1.680	5.382	1.350	
67	10%	Bottom	Left	Front	1.476	1.427	1.375	0.838	2.851	2.481	180
67	10%	Bottom	Left	Middle	1.077	0.384	0.471	0.747	1.824	0.996	179
67	10%	Bottom	Right	Back	1.370	1.366	1.452	0.157	2.822	2.071	180
67	10%	Bottom	Right	Front	1.940	0.232	1.908	1.389	3.848	0.356	178
67	10%	Bottom	Right	Middle	1.222	0.814	0.593	4.128	5.350	2.101	180
67	10%	Top	Left	Back	1.669	2.055	1.158	0.521	2.827	2.509	180
67	10%	Top	Left	Front	1.263	0.708	0.757	0.197	2.021	1.449	180
67	10%	Top	Left	Middle	1.271	0.748	1.508	0.808	2.779	1.849	180
67	10%	Top	Right	Back	1.799	2.355	0.102	1.025	2.824	4.544	180
67	10%	Top	Right	Front	3.109	1.156	4.875	2.245	7.984	1.435	179
67	10%	Top	Right	Middle	1.438	0.368	1.314	0.545	2.751	1.613	179
52	25%	Bottom	Left	Back	1.296		-0.603	0.123	1.419	1.352	
52	25%	Bottom	Left	Front	1.332	0.514	0.547	1.138	2.470	2.083	179
52	25%	Bottom	Left	Middle	0.969	1.040	0.207	0.508	1.477	1.939	180
52	25%	Bottom	Right	Back	2.107	1.771	-0.183	1.403	3.511	1.250	180
52	25%	Bottom	Right	Front	3.454	2.701	1.367	-0.110	4.821	3.943	180
52	25%	Bottom	Right	Middle	1.313	1.086	0.704	0.252	2.017	1.617	180
52	25%	Top	Left	Back	2.430	0.202	3.596	4.635	7.064	0.664	177
52	25%	Top	Left	Front	0.648	0.666	0.479	0.083	1.127	1.276	180
52	25%	Top	Left	Middle	1.055	0.082	3.398	3.470	4.525	0.624	177
52	25%	Top	Right	Back	14.921	0.664	6.656	5.616	21.577	1.595	175
52	25%	Top	Right	Front	1.332	1.411	2.051	0.409	3.383	1.683	180
52	25%	Top	Right	Middle	2.162		0.685	-0.623	2.847	0.978	
47	50%	Bottom	Left	Back	1.098	0.634	0.725	1.093	2.191	1.513	180
47	50%	Bottom	Left	Front	8.781	0.224	9.978	3.351	18.759	1.376	171
47	50%	Bottom	Left	Middle	2.280	0.154	3.750	3.942	6.222	0.798	177
47	50%	Bottom	Right	Back	0.931		0.695	-0.366	1.626	1.308	
47	50%	Bottom	Right	Front	2.175	0.180	4.467	2.762	6.643	0.356	177
47	50%	Bottom	Right	Middle	5.458	0.336	3.499	1.347	8.956	0.566	176
47	50%	Top	Left	Back	1.414	0.098	1.921	1.357	3.335	0.246	177
47	50%	Top	Left	Front	0.841	1.042	0.486	0.172	1.327	1.449	180
47	50%	Top	Left	Middle	1.105	1.553	0.888	0.208	1.993	1.947	180
47	50%	Top	Right	Back	2.648		1.810	-0.459	4.458	1.715	
47	50%	Top	Right	Front	2.095	1.649	-0.138	6.900	8.995	2.825	180
47	50%	Top	Right	Middle	6.821	0.124	10.166	8.703	16.987	0.320	167
60	75%	Bottom	Left	Back	1.512		-0.680	0.055	1.567	1.455	
60	75%	Bottom	Left	Front	1.816	1.102	6.309	0.562	8.125	1.531	180
60	75%	Bottom	Left	Middle	1.433		-0.387	0.885	2.318	1.018	
60	75%	Bottom	Right	Back	1.791	1.553	1.004	0.407	2.795	2.481	180
60	75%	Bottom	Right	Front	1.423	1.252	1.772	0.922	3.195	1.907	180
60	75%	Bottom	Right	Middle	0.727	0.522	0.290	1.070	1.796	1.623	180
60	75%	Top	Left	Back	7.292	0.558	3.209	4.512	11.804	0.928	177
60	75%	Top	Left	Front	2.924	1.248	0.868	7.256	10.180	1.671	179
60	75%	Top	Left	Middle	1.618	1.507	1.244	0.360	2.863	1.943	180
60	75%	Top	Right	Back	3.106	0.388	0.521	12.388	15.494	1.086	178
60	75%	Top	Right	Front	3.003	1.771	1.560	6.988	9.991	2.433	180
60	75%	Top	Right	Middle	2.490	1.675	1.157	0.851	3.647	2.217	180

	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
Minimum:	0.648	0.082	-0.680	-1.680	1.127	0.246	167
Maximum:	14.921	2.701	10.166	12.388	21.577	4.544	180

Table J.3c: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with an aluminium alloy 2024 T351 specimen subjected to a normal pressure of 100 MPa an axial stress amplitude of 125 MPa.

Specimen (no.)	Life proportion (%)	Scar		Trace	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
		T/B	L/R	F/M/B							
65	10%	Bottom	Left	Back	2.537		-1.193	1.130	3.667	1.449	
65	10%	Bottom	Left	Front	2.079		1.217	-1.127	3.296	0.794	
65	10%	Bottom	Left	Middle	2.736	3.133	1.300	-0.620	4.036	3.873	180
65	10%	Bottom	Right	Back	1.691		-0.703	0.868	2.559	1.082	
65	10%	Bottom	Right	Front	2.114	1.593	3.783	-0.052	5.897	1.749	180
65	10%	Bottom	Right	Middle	5.662	0.328	4.099	3.238	9.761	0.888	176
65	10%	Top	Left	Back	1.960		1.199	-1.047	3.159	1.016	
65	10%	Top	Left	Front	0.972	1.072	0.482	0.580	1.552	2.353	180
65	10%	Top	Left	Middle	1.156		-0.001	1.476	2.633	1.423	
65	10%	Top	Right	Back	3.157	2.627	1.077	-1.402	4.233	2.375	180
65	10%	Top	Right	Front	3.086		-1.442	0.845	3.931	1.216	
65	10%	Top	Right	Middle	1.446	1.096	0.290	0.565	2.011	1.579	180
44	25%	Bottom	Left	Back	0.797	0.302	0.440	1.035	1.831	0.430	179
44	25%	Bottom	Left	Front	6.425	0.402	4.031	2.846	10.456	0.934	176
44	25%	Bottom	Left	Middle	1.287		-0.347	0.842	2.129	0.962	
44	25%	Bottom	Right	Back	1.805	0.600	1.328	0.410	3.133	1.779	179
44	25%	Bottom	Right	Front	1.430		-0.799	1.127	2.558	1.230	
44	25%	Bottom	Right	Middle	1.663	2.641	-0.034	0.941	2.604	2.041	180
44	25%	Top	Left	Back	6.379	0.370	0.755	5.031	11.410	1.545	176
44	25%	Top	Left	Front	1.464	1.985	0.602	1.803	3.267	3.473	180
44	25%	Top	Left	Middle	1.543	1.619	0.213	0.739	2.282	3.547	180
44	25%	Top	Right	Back	1.040		0.066	-0.191	1.106	1.302	
44	25%	Top	Right	Front	2.172		0.573	-0.640	2.745	1.234	
44	25%	Top	Right	Middle	1.725		0.805	-0.760	2.530	1.539	
62	50%	Bottom	Left	Back	1.652	0.506	2.099	0.523	3.751	0.738	179
62	50%	Bottom	Left	Front	3.017	1.967	1.622	2.348	5.365	2.291	180
62	50%	Bottom	Left	Middle	3.969	0.476	2.853	3.310	7.280	0.918	178
62	50%	Bottom	Right	Back	1.386	1.270	3.125	1.174	4.510	1.835	180
62	50%	Bottom	Right	Front	1.355	1.220	0.456	2.121	3.477	3.615	180
62	50%	Bottom	Right	Middle	1.900		-1.300	1.866	3.766	1.314	
62	50%	Top	Left	Back	4.035	0.988	3.016	0.447	7.051	1.394	179
62	50%	Top	Left	Front	2.112	0.988	0.498	1.029	3.141	4.149	180
62	50%	Top	Left	Middle	6.084	0.886	0.840	4.733	10.817	1.338	178
62	50%	Top	Right	Back	1.908	1.609	3.899	0.048	5.807	2.049	180
62	50%	Top	Right	Front	5.681	0.462	3.632	14.864	20.545	0.676	177
62	50%	Top	Right	Middle	3.193	0.142	6.895	3.297	10.088	0.452	175
71	75%	Bottom	Left	Back	1.950	1.128	1.002	2.851	4.801	2.699	180
71	75%	Bottom	Left	Front	2.599	0.688	2.009	11.141	13.740	1.294	179
71	75%	Bottom	Left	Middle	1.607		-0.305	0.822	2.429	1.312	
71	75%	Bottom	Right	Back	1.959		-0.664	0.929	2.888	1.204	
71	75%	Bottom	Right	Front	1.951	0.258	3.904	2.328	5.856	0.918	178
71	75%	Bottom	Right	Middle	1.189	1.078	0.564	1.250	2.439	1.771	180
71	75%	Top	Left	Back	1.842	0.886	0.959	0.978	2.820	1.843	180
71	75%	Top	Left	Front	1.905	0.982	4.930	0.501	6.835	2.033	180
71	75%	Top	Left	Middle	2.630	0.132	2.627	3.981	6.610	0.312	175
71	75%	Top	Right	Back	4.337	0.930	2.777	0.569	7.114	1.364	179
71	75%	Top	Right	Front	1.909	0.472	0.628	1.817	3.726	1.473	179
71	75%	Top	Right	Middle	1.127		0.784	-0.075	1.910	1.439	

	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
Minimum:	0.797	0.132	-1.442	-1.402	1.106	0.312	175
Maximum:	6.425	3.133	6.895	14.864	20.545	4.149	180

J.4 PEENED: σ_a = 70 MPa

Table J.4a: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to a normal pressure of 10 MPa and an axial stress amplitude of 70 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
15P	10%	Bottom	Left	Back	9.74	0.22	10.51	6.00	20.250	0.678	170
15P	10%	Bottom	Left	Front	8.18	0.36	5.62	11.84	20.015	1.423	175
15P	10%	Bottom	Left	Middle	10.603	0.680	8.012	6.525	18.615	0.924	176
15P	10%	Bottom	Right	Back	6.57	0.63	3.28	6.25	12.816	0.948	178
15P	10%	Bottom	Right	Front	14.20	0.39	7.16	3.16	21.356	0.542	172
15P	10%	Bottom	Right	Middle	9.208		-6.135	4.206	13.413	0.570	
15P	10%	Top	Left	Back	9.66	0.55	7.03	1.97	16.686	1.268	176
15P	10%	Top	Left	Front	9.92	0.23	7.76	8.45	18.369	0.688	170
15P	10%	Top	Left	Middle	9.692	0.198	26.921	2.524	36.613	1.186	169
15P	10%	Top	Right	Back	8.93	0.69	3.89	6.88	15.809	2.543	177
15P	10%	Top	Right	Front	9.45	0.31	6.18	5.10	15.629	2.129	173
15P	10%	Top	Right	Middle	8.517	0.602	2.109	5.454	13.971	1.473	177
27P	25%	Bottom	Left	Back	9.34	0.78	11.32	4.82	20.658	1.893	177
27P	25%	Bottom	Left	Front	13.21	0.28	7.86	9.42	22.630	0.932	169
27P	25%	Bottom	Left	Middle	10.844	0.452	8.394	5.830	19.238	1.256	175
27P	25%	Bottom	Right	Back	11.75	0.24	14.25	2.01	26.003	0.724	169
27P	25%	Bottom	Right	Front	8.41	0.50	10.31	5.26	18.718	1.134	176
27P	25%	Bottom	Right	Middle	8.086	0.218	9.391	2.949	17.478	1.591	172
27P	25%	Top	Left	Back	13.94	0.47	7.88	14.20	28.143	1.633	173
27P	25%	Top	Left	Front	8.73	0.28	6.40	5.18	15.127	0.506	173
27P	25%	Top	Left	Middle	12.860	0.488	13.861	7.368	26.722	1.312	174
27P	25%	Top	Right	Back	11.07	0.36	7.82	5.00	18.888	0.962	173
27P	25%	Top	Right	Front	11.09	0.50	9.98	7.79	21.063	1.210	175
27P	25%	Top	Right	Middle	17.696	0.674	6.872	8.296	25.992	1.455	174
20P	75%	Bottom	Left	Back	11.45	0.65	7.24	7.35	18.793	2.351	176
20P	75%	Bottom	Left	Front	8.21	0.26	9.07	8.46	17.286	0.460	173
20P	75%	Bottom	Left	Middle	11.787	0.356	8.600	13.456	25.244	0.604	172
20P	75%	Bottom	Right	Back	9.13	0.45	8.23	1.36	17.363	1.156	175
20P	75%	Bottom	Right	Front	9.06		-3.02	8.68	17.734	0.482	
20P	75%	Bottom	Right	Middle	11.429	0.472	5.046	6.023	17.452	1.701	174
20P	75%	Top	Left	Back	8.36	0.71	6.90	8.04	16.405	1.943	177
20P	75%	Top	Left	Front	12.27	0.47	9.50	1.67	21.775	1.224	174
20P	75%	Top	Left	Middle	9.060	0.668	4.367	7.237	16.297	1.198	177
20P	75%	Top	Right	Back	11.84	0.48	5.53	10.11	21.943	1.583	174
20P	75%	Top	Right	Front	8.70	0.24	9.96	9.30	18.659	1.244	172
20P	75%	Top	Right	Middle	12.018	0.300	6.090	9.332	21.349	1.919	171
Minimum:					6.57	0.20	-6.13	1.36	12.82	0.46	169
Maximum:					17.70	0.78	26.92	14.20	36.61	2.54	178

Table J.4b: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to a normal pressure of 60 MPa and an axial stress amplitude of 70 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
32P	10%	Bottom	Left	Back	12.59	0.94	5.60	12.41	24.994	1.947	177
32P	10%	Bottom	Left	Front	14.15	0.42	7.51	5.34	21.663	1.064	172
32P	10%	Bottom	Left	Middle	8.046	0.398	10.037	7.859	18.083	1.727	175
32P	10%	Bottom	Right	Back	8.08	0.32	2.42	5.20	13.284	1.421	174
32P	10%	Bottom	Right	Front	12.64	0.38	8.86	5.96	21.502	1.811	172
32P	10%	Bottom	Right	Middle	11.367	0.322	3.392	8.211	19.578	0.504	172
32P	10%	Top	Left	Back	7.86	0.20	4.67	4.83	12.693	1.258	171
32P	10%	Top	Left	Front	10.20		-0.13	4.37	14.573	1.000	
32P	10%	Top	Left	Middle	13.183	0.348	3.314	9.151	22.334	2.869	171
32P	10%	Top	Right	Back	9.62	0.64	10.43	3.96	20.043	1.128	177
32P	10%	Top	Right	Front	10.07	0.54	7.67	4.86	17.736	1.725	176
32P	10%	Top	Right	Middle	9.585	0.482	6.267	10.246	19.831	1.142	175
18P	25%	Bottom	Left	Back	10.98	0.35	16.60	7.53	27.582	2.313	173
18P	25%	Bottom	Left	Front	11.08	0.71	5.76	4.20	16.840	2.515	176
18P	25%	Bottom	Left	Middle	10.735	0.306	5.314	12.519	23.254	1.152	172
18P	25%	Bottom	Right	Back	13.20		11.18	-7.67	24.377	0.722	
18P	25%	Bottom	Right	Front	26.55		-14.62	57.03	83.576	1.156	
18P	25%	Bottom	Right	Middle	9.778	1.050	5.961	7.695	17.473	1.897	178
18P	25%	Top	Left	Back	8.32	0.49	6.04	10.05	18.368	1.010	176
18P	25%	Top	Left	Front	11.25	0.51	13.77	6.15	25.023	1.829	175
18P	25%	Top	Left	Middle	7.750	0.522	7.328	5.600	15.078	1.252	177
18P	25%	Top	Right	Back	9.40	0.39	10.67	6.09	20.065	1.531	174
18P	25%	Top	Right	Front	12.96	0.49	13.47	3.81	26.437	0.956	174
18P	25%	Top	Right	Middle	7.209		-2.650	8.234	15.442	0.414	
14P	50%	Bottom	Left	Back	4.77	0.67	4.58	7.61	12.375	1.549	178
14P	50%	Bottom	Left	Front	9.06	0.81	3.53	5.88	14.942	0.974	177
14P	50%	Bottom	Left	Middle	13.591	0.570	5.468	4.120	19.059	1.673	175
14P	50%	Bottom	Right	Back	9.95	0.58	5.41	3.98	15.359	1.296	176
14P	50%	Bottom	Right	Front	10.11	0.39	6.17	3.53	16.285	1.292	174
14P	50%	Bottom	Right	Middle	9.123	0.388	5.554	6.668	15.791	1.382	175
14P	50%	Top	Left	Back	8.76	0.41	10.04	6.41	18.794	0.800	175
14P	50%	Top	Left	Front	9.16	0.29	10.03	8.76	19.198	1.805	173
14P	50%	Top	Left	Middle	15.731	0.686	2.208	6.492	22.224	1.130	175
14P	50%	Top	Right	Back	11.10	0.48	7.77	9.71	20.810	1.140	175
14P	50%	Top	Right	Front	9.66	0.48	6.54	5.95	16.209	0.972	175
14P	50%	Top	Right	Middle	16.357	0.716	10.032	5.014	26.389	1.266	175

	Depth	Width	Left peak	Right peak	h	l	θ
Minimum:	4.77	0.20	-14.62	-7.67	12.38	0.41	171
Maximum:	26.55	1.05	16.60	57.03	83.58	2.87	178

Table J.4c: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to a normal pressure of 100 MPa an axial stress amplitude of 70 MPa.

Specimen	Life proportion	Scar		Trace	Depth	Width	Left peak	Right peak	h	l	θ
(no.)	(%)	T/B	L/R	F/M/B	(μm)	(mm)	(μm)	(μm)	(μm)	(mm)	(°)
43P	10%	Bottom	Left	Back	10.83	0.23	2.33	5.91	16.741	0.390	169
43P	10%	Bottom	Left	Front	9.44	0.39	5.00	9.51	18.944	1.272	175
43P	10%	Bottom	Left	Middle	13.128	0.582	7.504	6.599	20.632	1.755	175
43P	10%	Bottom	Right	Back	7.92	0.30	7.02	8.79	16.709	1.973	174
43P	10%	Bottom	Right	Front	8.36	0.32	7.47	6.05	15.829	1.056	174
43P	10%	Bottom	Right	Middle	9.511	0.396	5.281	9.687	19.199	0.796	174
43P	10%	Top	Left	Back	7.13	0.70	4.48	7.15	14.273	0.934	178
43P	10%	Top	Left	Front	8.97	0.20	7.87	7.24	16.843	1.703	170
43P	10%	Top	Left	Middle	7.668	0.244	7.082	5.943	14.751	1.421	173
43P	10%	Top	Right	Back	9.80	0.68	1.71	9.71	19.508	0.942	177
43P	10%	Top	Right	Front	9.27	0.25	7.25	7.11	16.522	2.391	172
43P	10%	Top	Right	Middle	9.487	0.236	10.790	8.471	20.277	0.498	171
19P	25%	Bottom	Left	Back	9.51	0.36	3.75	4.45	13.953	1.174	174
19P	25%	Bottom	Left	Front	16.21	0.32	10.28	5.22	26.491	0.826	168
19P	25%	Bottom	Left	Middle	8.716	0.610	11.330	5.831	20.046	1.747	177
19P	25%	Bottom	Right	Back	7.90	0.27	6.66	2.30	14.565	0.762	173
19P	25%	Bottom	Right	Front	9.09	0.49	8.88	7.84	17.972	1.709	176
19P	25%	Bottom	Right	Middle	11.211	0.938	12.669	5.235	23.880	1.543	177
19P	25%	Top	Left	Back	8.47	0.58	0.79	5.09	13.557	1.773	177
19P	25%	Top	Left	Front	11.79	0.28	4.91	8.21	20.001	0.530	170
19P	25%	Top	Left	Middle	8.732	0.244	6.152	11.377	20.109	1.585	172
19P	25%	Top	Right	Back	13.68	0.87	8.16	12.44	26.119	2.493	176
19P	25%	Top	Right	Front	12.08	0.42	12.97	8.60	25.050	1.304	173
19P	25%	Top	Right	Middle	9.179	0.274	4.076	7.477	16.656	1.044	172
26P	50%	Bottom	Left	Back	13.05	0.91	7.63	4.55	20.680	1.735	177
26P	50%	Bottom	Left	Front	8.96	0.52	3.04	5.97	14.937	0.850	176
26P	50%	Bottom	Left	Middle	18.218	0.530	7.209	4.961	25.427	1.895	172
26P	50%	Bottom	Right	Back	10.07	0.37	5.48	10.60	20.665	0.626	174
26P	50%	Bottom	Right	Front	8.02	0.53	7.93	5.45	15.956	1.809	177
26P	50%	Bottom	Right	Middle	12.988	0.276	6.415	4.278	19.403	0.758	169
26P	50%	Top	Left	Back	11.14	0.66	10.55	6.26	21.692	1.611	176
26P	50%	Top	Left	Front	7.25	0.45	10.54	4.86	17.794	0.880	176
26P	50%	Top	Left	Middle	10.811	0.576	5.198	6.103	16.915	2.357	176
26P	50%	Top	Right	Back	10.12	0.27	4.74	5.54	15.662	1.919	171
26P	50%	Top	Right	Front	9.81	0.36	6.00	7.70	17.511	0.606	174
26P	50%	Top	Right	Middle	6.710	0.420	8.404	3.024	15.115	1.437	176
28P	75%	Bottom	Left	Back	11.60	0.26	4.70	6.12	17.713	0.480	170
28P	75%	Bottom	Left	Front	10.82	0.52	6.36	6.68	17.501	1.587	175
28P	75%	Bottom	Left	Middle	9.455	0.688	10.777	6.784	20.232	1.565	177
28P	75%	Bottom	Right	Back	7.11	0.69	6.53	3.47	13.637	1.160	178
28P	75%	Bottom	Right	Front	12.01	0.53	4.31	7.38	19.385	1.380	175
28P	75%	Bottom	Right	Middle	17.388	0.332	10.585	5.949	27.972	1.773	168
28P	75%	Top	Left	Back	7.86	0.24	4.36	11.45	19.315	0.802	172
28P	75%	Top	Left	Front	11.27	0.41	6.19	7.23	18.500	1.018	174
28P	75%	Top	Left	Middle	10.616	0.666	1.884	9.470	20.086	1.342	176
28P	75%	Top	Right	Back	8.70	0.32	6.05	9.05	17.745	1.220	174
28P	75%	Top	Right	Front	12.61	1.07	4.62	9.79	22.402	1.783	177
28P	75%	Top	Right	Middle	10.228	0.510	7.424	5.872	17.652	1.220	175

	Depth	Width	Left peak	Right peak	h	l	θ
Minimum:	6.71	0.20	0.79	2.30	13.56	0.39	168
Maximum:	18.22	1.07	12.97	12.44	27.97	2.49	178

J.5 PEENED: σ_a = 100 MPa

Table J.5a: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to a normal pressure of 10 MPa and an axial stress amplitude of 100 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
45P	10%	Bottom	Left	Back	11.228	0.324	2.576	7.196	18.423	1.154	172
45P	10%	Bottom	Left	Front	9.585	0.260	7.121	5.634	16.707	0.530	172
45P	10%	Bottom	Left	Middle	9.232	0.322	4.825	10.963	20.195	0.608	173
45P	10%	Bottom	Right	Back	9.522	0.292	4.765	10.451	19.974	0.810	173
45P	10%	Bottom	Right	Front	10.315		5.612	-5.794	15.927	1.150	
45P	10%	Bottom	Right	Middle	8.901	0.446	10.092	4.103	18.993	0.720	175
45P	10%	Top	Left	Back	10.037	0.216	8.854	7.959	18.891	0.430	169
45P	10%	Top	Left	Front	20.058	0.740	7.775	8.778	28.836	1.643	174
45P	10%	Top	Left	Middle	7.042	0.368	9.475	8.098	16.516	1.463	176
45P	10%	Top	Right	Back	10.004	0.600	7.551	1.719	17.555	1.258	176
45P	10%	Top	Right	Front	9.507	0.356	4.885	6.634	16.141	0.956	174
45P	10%	Top	Right	Middle	9.529	0.386	6.800	4.832	16.329	1.142	174
22P	25%	Bottom	Left	Back	14.061	0.296	7.432	10.481	24.542	1.170	169
22P	25%	Bottom	Left	Front	11.348	0.272	12.818	11.635	24.165	0.940	170
22P	25%	Bottom	Left	Middle	11.071	0.306	6.472	5.945	17.543	1.545	172
22P	25%	Bottom	Right	Back	6.976	0.440	4.155	7.130	14.106	0.662	176
22P	25%	Bottom	Right	Front	8.877		12.036	-5.639	20.913	0.764	
22P	25%	Bottom	Right	Middle	14.781	0.364	8.719	7.228	23.501	1.675	171
22P	25%	Top	Left	Back	9.549	0.754	9.839	5.769	19.388	1.376	177
22P	25%	Top	Left	Front	8.936	0.412	7.334	10.772	19.708	1.869	175
22P	25%	Top	Left	Middle	13.908	0.558	3.834	8.315	22.223	1.549	174
22P	25%	Top	Right	Back	10.650		6.979	-1.029	17.629	1.114	
22P	25%	Top	Right	Front	9.393	0.564	8.405	0.965	17.798	1.164	176
22P	25%	Top	Right	Middle	9.333		5.489	-0.966	14.822	1.336	
12P	50%	Bottom	Left	Back	9.310	0.296	10.154	7.028	19.464	1.747	173
12P	50%	Bottom	Left	Front	10.069	0.470	8.908	7.273	18.977	1.038	175
12P	50%	Bottom	Left	Middle	7.620	0.416	6.196	4.293	13.815	1.108	176
12P	50%	Bottom	Right	Back	10.573	1.403	10.604	2.118	21.176	2.421	178
12P	50%	Bottom	Right	Front	7.173	0.970	4.217	8.499	15.672	1.585	178
12P	50%	Bottom	Right	Middle	10.666	0.234	4.759	7.570	18.236	0.542	170
12P	50%	Top	Left	Back	8.904	0.646	0.789	6.149	15.053	1.182	177
12P	50%	Top	Left	Front	14.435	0.792	6.663	3.733	21.098	0.968	176
12P	50%	Top	Left	Middle	7.298	0.230	12.253	4.575	19.551	1.631	173
12P	50%	Top	Right	Back	13.078	0.278	7.293	8.852	21.930	1.931	169
12P	50%	Top	Right	Front	12.096	0.246	6.706	7.641	19.737	1.605	169
12P	50%	Top	Right	Middle	9.766	0.258	4.316	7.121	16.887	1.717	171
Minimum:					6.98	0.22	0.79	-5.79	13.82	0.43	169
Maximum:					20.06	1.40	12.82	11.63	28.84	2.42	178

Table J.5b: The scar depths, widths and peaks and calculated values h, l and □, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to a normal pressure of 40 MPa and an axial stress amplitude of 100 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
17P	10%	Bottom	Left	Back	17.381	0.582	8.658	8.358	26.039	1.411	173
17P	10%	Bottom	Left	Front	10.044	0.262	6.169	8.055	18.100	0.462	171
17P	10%	Bottom	Left	Middle	13.852	0.540	3.301	4.846	18.698	2.493	174
17P	10%	Bottom	Right	Back	11.392	0.548	6.464	11.138	22.529	1.819	175
17P	10%	Bottom	Right	Front	7.590		5.168	-4.556	12.757	0.938	
17P	10%	Bottom	Right	Middle	7.145	0.440	3.335	6.624	13.770	1.338	176
17P	10%	Top	Left	Back	11.491	0.424	7.273	5.195	18.764	0.688	174
17P	10%	Top	Left	Front	8.855	0.396	9.350	5.116	18.205	1.455	175
17P	10%	Top	Left	Middle	11.869	0.862	11.068	3.673	22.937	1.413	177
17P	10%	Top	Right	Back	9.130		10.731	-0.795	19.861	0.974	
17P	10%	Top	Right	Front	24.052	0.200	6.236	12.244	36.296	0.896	153
17P	10%	Top	Right	Middle	12.123	0.914	4.756	2.155	16.878	1.110	177
34P	50%	Bottom	Left	Back	10.422	0.236	6.415	5.481	16.837	1.977	170
34P	50%	Bottom	Left	Front	9.998	0.290	11.913	0.985	21.911	1.977	172
34P	50%	Bottom	Left	Middle	8.453	0.584	7.870	6.928	16.323	1.719	177
34P	50%	Bottom	Right	Back	9.697	0.324	5.390	10.138	19.835	0.984	173
34P	50%	Bottom	Right	Front	7.581	0.528	8.316	8.771	16.352	1.437	177
34P	50%	Bottom	Right	Middle	15.349	0.230	7.944	16.850	32.200	0.834	165
34P	50%	Top	Left	Back	8.844	0.700	6.027	8.607	17.450	1.597	177
34P	50%	Top	Left	Front	10.704		10.735	-0.455	21.439	0.998	
34P	50%	Top	Left	Middle	10.610	0.424	6.094	4.567	16.704	1.673	174
34P	50%	Top	Right	Back	11.559	0.356	12.766	4.058	24.326	2.469	173
34P	50%	Top	Right	Front	8.045	0.312	0.666	5.288	13.333	1.517	174
34P	50%	Top	Right	Middle	7.595	0.320	1.547	7.982	15.577	1.571	175
29P	75%	Bottom	Left	Back	9.233	0.410	6.405	6.405	15.638	1.681	175
29P	75%	Bottom	Left	Front	9.611	0.234	6.033	5.144	15.643	1.651	171
29P	75%	Bottom	Left	Middle	9.606	0.358	6.296	7.024	16.629	0.832	174
29P	75%	Bottom	Right	Back	14.257	0.226	7.740	9.710	23.966	0.652	166
29P	75%	Bottom	Right	Front	8.931	0.258	3.788	8.065	16.996	1.178	172
29P	75%	Bottom	Right	Middle	15.359	0.710	9.423	9.751	25.109	1.559	175
29P	75%	Top	Left	Back	9.003	0.236	6.358	4.008	15.362	1.222	171
29P	75%	Top	Left	Front	9.050	0.388	7.965	8.499	17.548	0.706	175
29P	75%	Top	Left	Middle	9.110	0.492	7.202	4.260	16.312	1.481	176
29P	75%	Top	Right	Back	8.994		-0.142	8.743	17.737	0.700	
29P	75%	Top	Right	Front	10.401	0.544	6.867	6.577	17.267	1.348	176
29P	75%	Top	Right	Middle	9.470	0.306	9.391	3.690	18.861	1.306	173

	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
Minimum:	7.15	0.20	-0.14	-4.56	12.76	0.46	153
Maximum:	24.05	0.91	12.77	16.85	36.30	2.49	177

Table J.5c: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to a normal pressure of 100 MPa an axial stress amplitude of 100 MPa.

Specimen	Life proportion	Scar		Trace	Depth	Width	Left peak	Right peak	h	l	θ
(no.)	(%)	T/B	L/R	F/M/B	(μm)	(mm)	(μm)	(μm)	(μm)	(mm)	(°)
16P	10%	Bottom	Left	Back	7.934		3.930	-4.410	11.864	0.574	
16P	10%	Bottom	Left	Front	12.872	0.400	6.646	3.143	19.518	1.731	173
16P	10%	Bottom	Left	Middle	6.835	0.354	9.056	4.223	15.891	0.712	176
16P	10%	Bottom	Right	Back	9.846	0.302	7.786	4.960	17.632	1.619	173
16P	10%	Bottom	Right	Front	8.541		8.649	-3.530	17.190	1.194	
16P	10%	Bottom	Right	Middle	7.308	0.598	5.031	8.223	15.531	2.087	177
16P	10%	Top	Left	Back	10.774	0.784	7.471	5.800	18.246	1.054	177
16P	10%	Top	Left	Front	11.133	0.266	9.456	5.417	20.590	1.142	170
16P	10%	Top	Left	Middle	14.168	0.462	9.138	10.204	24.372	1.198	173
16P	10%	Top	Right	Back	12.363	0.832	6.526	2.078	18.889	1.577	177
16P	10%	Top	Right	Front	11.507		-6.198	8.681	20.188	0.982	
16P	10%	Top	Right	Middle	10.197	0.650	10.520	0.145	20.717	0.798	176
39P	50%	Bottom	Left	Back	10.230	0.558	6.360	4.248	16.590	1.324	176
39P	50%	Bottom	Left	Front	8.464	0.276	6.704	5.250	15.169	1.134	173
39P	50%	Bottom	Left	Middle	9.074	0.580	2.786	6.255	15.329	1.378	176
39P	50%	Bottom	Right	Back	15.188	0.586	4.609	5.116	20.304	1.575	174
39P	50%	Bottom	Right	Front	11.824		3.143	-1.299	14.966	1.212	
39P	50%	Bottom	Right	Middle	9.347	0.414	2.099	7.502	16.849	1.411	175
39P	50%	Top	Left	Back	10.901	0.468	7.563	5.455	18.465	1.751	175
39P	50%	Top	Left	Front	10.237	0.962	9.617	5.219	19.854	1.751	178
39P	50%	Top	Left	Middle	11.638	0.424	7.369	4.720	19.007	2.309	174
39P	50%	Top	Right	Back	12.189	0.764	10.740	6.736	22.929	1.543	176
39P	50%	Top	Right	Front	6.817	1.332	7.662	8.755	15.572	2.101	179
39P	50%	Top	Right	Middle	10.938	0.260	4.695	7.551	18.489	1.499	170
24P	75%	Bottom	Left	Back	7.664	0.246	7.127	9.746	17.410	1.190	173
24P	75%	Bottom	Left	Front	14.649	0.362	9.169	6.830	23.818	1.248	171
24P	75%	Bottom	Left	Middle	8.282	0.560	8.430	5.748	16.712	1.985	177
24P	75%	Bottom	Right	Back	9.927	0.264	10.154	4.719	20.081	0.874	171
24P	75%	Bottom	Right	Front	10.609	0.496	3.470	6.263	16.871	1.869	175
24P	75%	Bottom	Right	Middle	7.348	0.422	7.464	3.832	14.813	0.994	176
24P	75%	Top	Left	Back	12.049	0.586	6.806	9.125	21.174	0.888	175
24P	75%	Top	Left	Front	12.024	0.626	5.756	4.219	17.781	1.501	176
24P	75%	Top	Left	Middle	9.745	0.744	5.644	4.088	15.389	1.797	177
24P	75%	Top	Right	Back	10.093		8.602	-3.688	18.695	1.579	
24P	75%	Top	Right	Front	9.470	0.632	6.082	7.551	17.020	1.813	177
24P	75%	Top	Right	Middle	7.976	0.204	5.989	6.448	14.424	0.484	171

	Depth	Width	Left peak	Right peak	h	l	θ
Minimum:	6.82	0.20	-6.20	-4.41	11.86	0.48	170
Maximum:	15.19	1.33	10.74	10.20	24.37	2.31	179

J.6 PEENED: σ_a = 125 MPa

Table J.6a: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to a normal pressure of 10 MPa and an axial stress amplitude of 125 MPa.

Specimen	Life proportion	Scar		Trace	Depth	Width	Left peak	Right peak	h	l	θ
(no.)	(%)	T/B	L/R	F/M/B	(μm)	(mm)	(μm)	(μm)	(μm)	(mm)	(°)
38P	10%	Bottom	Left	Back	13.506	0.624	5.351	5.140	18.857	2.071	175
38P	10%	Bottom	Left	Front	9.089	0.538	6.396	5.561	15.485	2.023	176
38P	10%	Bottom	Left	Middle	7.835	0.558	6.595	7.976	15.811	1.344	177
38P	10%	Bottom	Right	Back	12.397	1.204	6.167	7.691	20.088	1.443	178
38P	10%	Bottom	Right	Front	11.692	0.662	3.833	11.367	23.059	1.725	176
38P	10%	Bottom	Right	Middle	8.760	0.596	3.780	7.686	16.446	1.821	177
38P	10%	Top	Left	Back	24.160		-0.685	35.639	59.799	1.757	
38P	10%	Top	Left	Front	41.631	0.680	14.819	6.736	56.450	1.653	166
38P	10%	Top	Left	Middle	15.417		43.243	-6.372	58.660	1.671	
38P	10%	Top	Right	Back	12.046	0.646	7.471	8.584	20.630	1.376	176
38P	10%	Top	Right	Front	9.477	0.632	1.185	4.413	13.890	1.721	177
38P	10%	Top	Right	Middle	8.039	0.578	2.962	4.465	12.504	1.443	177
13P	50%	Bottom	Left	Back	10.494	0.480	5.311	6.404	16.898	0.756	175
13P	50%	Bottom	Left	Front	22.423	1.326	9.737	15.163	37.586	1.767	176
13P	50%	Bottom	Left	Middle	8.019	0.314	6.432	0.803	14.451	0.488	174
13P	50%	Bottom	Right	Back	65.359	1.499	16.701	27.915	93.274	2.171	170
13P	50%	Bottom	Right	Front	94.749	1.627	20.292	29.870	124.619	2.019	167
13P	50%	Bottom	Right	Middle	51.182	0.596	15.665	8.804	66.847	1.833	161
13P	50%	Top	Left	Back	19.904	0.890	11.209	6.262	31.113	1.292	175
13P	50%	Top	Left	Front	10.443	0.720	10.116	4.560	20.559	0.954	177
13P	50%	Top	Left	Middle	22.495	0.992	6.213	7.132	29.626	3.663	175
13P	50%	Top	Right	Back	12.488	0.274	7.824	6.697	20.312	1.641	170
13P	50%	Top	Right	Front	9.179	0.408	6.053	13.339	22.518	1.008	175
13P	50%	Top	Right	Middle	7.380	0.664	10.306	6.185	17.686	2.051	177

	Depth	Width	Left peak	Right peak	h	l	θ
Minimum:	7.38	0.27	-0.68	-6.37	12.50	0.49	161
Maximum:	94.75	1.63	43.24	35.64	124.62	3.66	178

Table J.6b: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to a normal pressure of 60 MPa and an axial stress amplitude of 125 MPa.

Specimen (no.)	Life proportion (%)	Scar T/B	Scar L/R	Trace F/M/B	Depth (μm)	Width (mm)	Left peak (μm)	Right peak (μm)	h (μm)	l (mm)	θ (°)
33P	10%	Bottom	Left	Back	8.262	0.450	8.757	9.619	17.881	1.130	176
33P	10%	Bottom	Left	Front	9.333	0.290	10.953	3.618	20.286	1.070	173
33P	10%	Bottom	Left	Middle	10.768	0.742	4.175	3.887	14.944	2.091	177
33P	10%	Bottom	Right	Back	31.932	0.754	7.684	11.144	43.076	1.741	170
33P	10%	Bottom	Right	Front	11.087	1.603	-0.299	4.864	15.952	0.766	178
33P	10%	Bottom	Right	Middle	6.926	0.672	5.730	5.088	12.656	2.023	178
33P	10%	Top	Left	Back	17.270	0.412	11.481	17.305	34.576	1.342	170
33P	10%	Top	Left	Front	7.796	0.438	10.593	5.459	18.389	1.356	176
33P	10%	Top	Left	Middle	11.250	0.748	10.194	2.666	21.444	1.427	177
33P	10%	Top	Right	Back	17.983	0.750	6.147	6.768	24.751	2.167	175
33P	10%	Top	Right	Front	9.599	0.490	6.359	7.088	16.687	1.883	176
33P	10%	Top	Right	Middle	7.760	0.558	1.809	10.526	18.286	1.142	177
42P	25%	Bottom	Left	Back	9.209	0.442	0.383	9.519	18.728	0.754	175
42P	25%	Bottom	Left	Front	8.351	0.278	7.896	6.765	16.246	0.978	173
42P	25%	Bottom	Left	Middle	8.147	0.536	4.262	0.015	12.409	1.258	177
42P	25%	Bottom	Right	Back	17.338	1.380	1.902	23.649	40.987	1.697	177
42P	25%	Bottom	Right	Front	10.787	0.608	2.584	2.977	13.764	1.278	176
42P	25%	Bottom	Right	Middle	13.509	0.622	6.936	4.802	20.445	0.810	175
42P	25%	Top	Left	Back	9.037		4.506	-0.578	13.543	0.966	
42P	25%	Top	Left	Front	7.787	0.612	5.618	6.622	14.408	2.135	177
42P	25%	Top	Left	Middle	9.347	0.252	9.681	4.975	19.028	1.467	172
42P	25%	Top	Right	Back	12.775	0.434	6.444	4.486	19.220	1.465	173
42P	25%	Top	Right	Front	8.544	0.570	7.095	2.693	15.639	2.285	177
42P	25%	Top	Right	Middle	7.463		5.339	-4.242	12.803	0.564	
23P	50%	Bottom	Left	Back	9.557	0.416	9.152	8.831	18.709	1.236	175
23P	50%	Bottom	Left	Front	21.381		-2.389	49.700	71.081	1.254	
23P	50%	Bottom	Left	Middle	8.868	0.292	0.514	6.256	15.124	1.429	173
23P	50%	Bottom	Right	Back	7.084	0.180	3.084	6.213	13.297	1.242	171
23P	50%	Bottom	Right	Front	11.450	0.772	5.489	8.287	19.737	1.194	177
23P	50%	Bottom	Right	Middle	13.301	0.796	8.829	3.462	22.130	1.154	176
23P	50%	Top	Left	Back	10.378		-6.142	7.195	17.574	1.308	
23P	50%	Top	Left	Front	7.347	0.612	11.591	8.661	18.939	2.545	177
23P	50%	Top	Left	Middle	10.394	0.202	5.550	7.167	17.561	1.100	168
23P	50%	Top	Right	Back	10.017	0.512	2.305	6.160	16.177	0.702	176
23P	50%	Top	Right	Front	13.665	0.638	14.286	5.758	27.951	1.232	175
23P	50%	Top	Right	Middle	8.916	0.352	6.801	14.632	23.548	0.868	174
Minimum:					6.93	0.18	-6.14	-4.24	12.41	0.56	168
Maximum:					31.93	1.60	14.29	49.70	71.08	2.55	178

Table J.6c: The scar depths, widths and peaks and calculated values h, l and θ, for the fretting fatigue tests with an aluminium alloy 2024 T351 bridge in contact with a shot peened aluminium alloy 2024 T351 specimen subjected to a normal pressure of 100 MPa an axial stress amplitude of 125 MPa.

Specimen	Life proportion	Scar		Trace	Depth	Width	Left peak	Right peak	h	l	θ
(no.)	(%)	T/B	L/R	F/M/B	(μm)	(mm)	(μm)	(μm)	(μm)	(mm)	(°)
36P	10%	Bottom	Left	Back	12.032	0.998	4.559	2.146	16.591	3.475	177
36P	10%	Bottom	Left	Front	13.960	1.196	6.203	6.140	20.163	4.414	177
36P	10%	Bottom	Left	Middle	11.123	1.603	11.225	-1.455	22.349	1.949	178
36P	10%	Bottom	Right	Back	14.694	1.098	6.204	9.184	23.878	2.179	177
36P	10%	Bottom	Right	Front	11.169	0.422	5.166	5.671	16.840	1.196	174
36P	10%	Bottom	Right	Middle	12.920	0.714	9.844	9.931	22.851	1.547	176
36P	10%	Top	Left	Back	11.278	0.614	11.115	8.827	22.392	2.123	176
36P	10%	Top	Left	Front	8.805		-1.179	6.516	15.321	0.628	
36P	10%	Top	Left	Middle	9.547	0.536	6.836	4.193	16.383	2.239	176
36P	10%	Top	Right	Back	10.317		-1.192	11.137	21.454	0.530	
36P	10%	Top	Right	Front	7.162	0.610	3.484	4.677	11.839	1.417	177
36P	10%	Top	Right	Middle	9.836	0.238	4.463	6.237	16.074	0.402	171
37P	25%	Bottom	Left	Back	7.544	0.348	7.917	3.663	15.461	0.572	175
37P	25%	Bottom	Left	Front	13.352	0.830	10.826	6.707	24.178	1.619	176
37P	25%	Bottom	Left	Middle	7.222		6.151	-2.538	13.373	1.521	
37P	25%	Bottom	Right	Back	8.458	0.338	4.116	5.902	14.360	0.914	174
37P	25%	Bottom	Right	Front	9.871	0.334	7.729	4.919	17.600	1.599	173
37P	25%	Bottom	Right	Middle	7.311	0.766	7.387	6.620	14.698	2.467	178
37P	25%	Top	Left	Back	8.938		15.988	-2.160	24.926	1.228	
37P	25%	Top	Left	Front	11.276		6.705	-2.312	17.981	0.714	
37P	25%	Top	Left	Middle	8.111	0.258	4.141	5.720	13.831	1.330	173
37P	25%	Top	Right	Back	14.711	0.288	5.099	7.789	22.501	1.567	168
37P	25%	Top	Right	Front	9.983	0.280	6.336	6.582	16.566	0.694	172
37P	25%	Top	Right	Middle	9.638	0.278	6.528	8.513	18.151	1.292	172
21P	50%	Bottom	Left	Back	9.461	0.576	4.046	9.422	18.884	1.280	176
21P	50%	Bottom	Left	Front	7.823	0.528	8.367	9.319	17.142	1.537	177
21P	50%	Bottom	Left	Middle	10.545	0.316	1.399	4.593	15.138	0.906	172
21P	50%	Bottom	Right	Back	8.095	0.384	11.053	4.864	19.148	1.667	175
21P	50%	Bottom	Right	Front	8.053	0.646	6.936	9.257	17.310	1.122	177
21P	50%	Bottom	Right	Middle	7.936	0.262	7.782	8.103	16.038	0.490	173
21P	50%	Top	Left	Back	7.865	0.306	11.539	2.153	19.404	0.584	174
21P	50%	Top	Left	Front	7.580	0.402	6.440	6.338	14.020	0.882	176
21P	50%	Top	Left	Middle	11.353	0.374	6.132	6.547	17.900	0.728	173
21P	50%	Top	Right	Back	8.940	0.336	9.315	9.365	18.305	1.441	174
21P	50%	Top	Right	Front	9.673	0.280	5.116	2.811	14.789	1.517	172
21P	50%	Top	Right	Middle	10.668	0.316	1.848	10.896	21.564	1.348	172

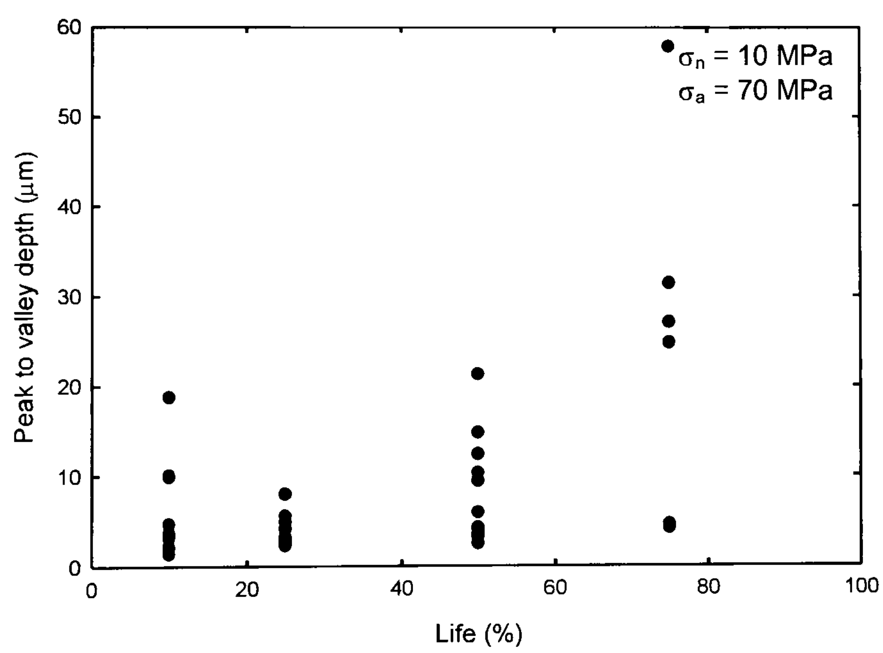
	Depth	Width	Left peak	Right peak	h	l	θ
Minimum:	7.16	0.24	-1.19	-2.54	11.84	0.40	168
Maximum:	14.71	1.60	15.99	11.14	24.93	4.41	178

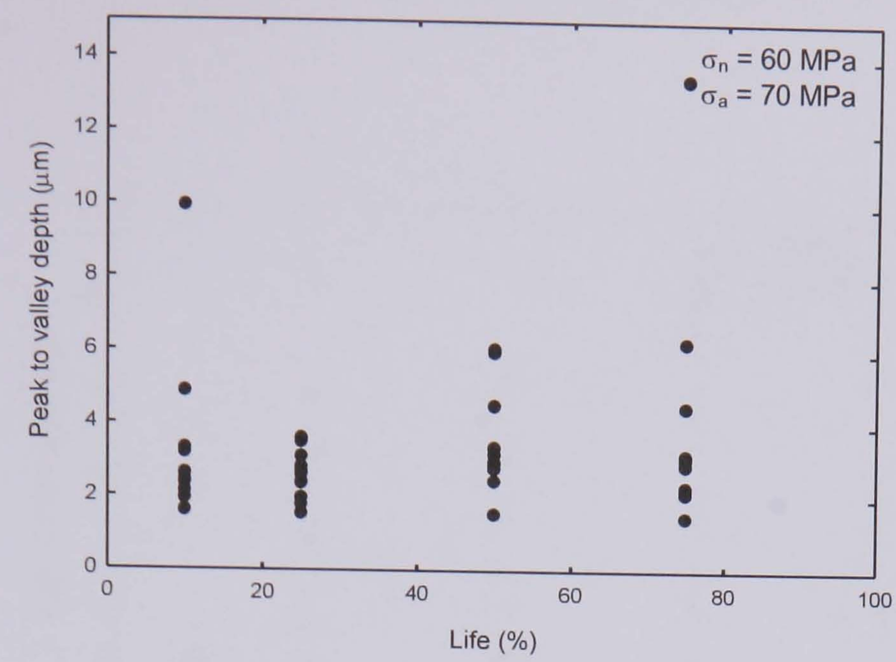
APPENDIX K

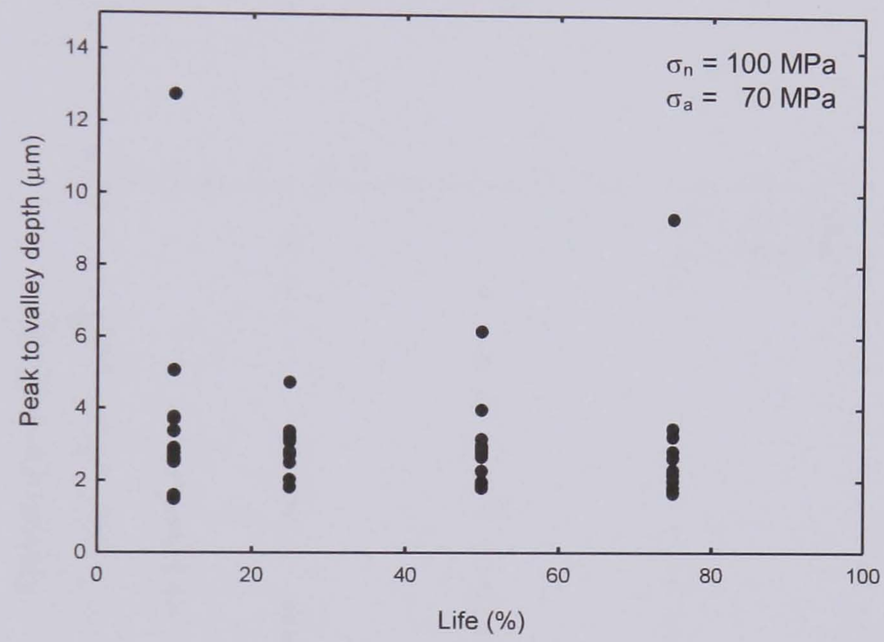
RESULTS: PEAK TO VALLEY DEPTH

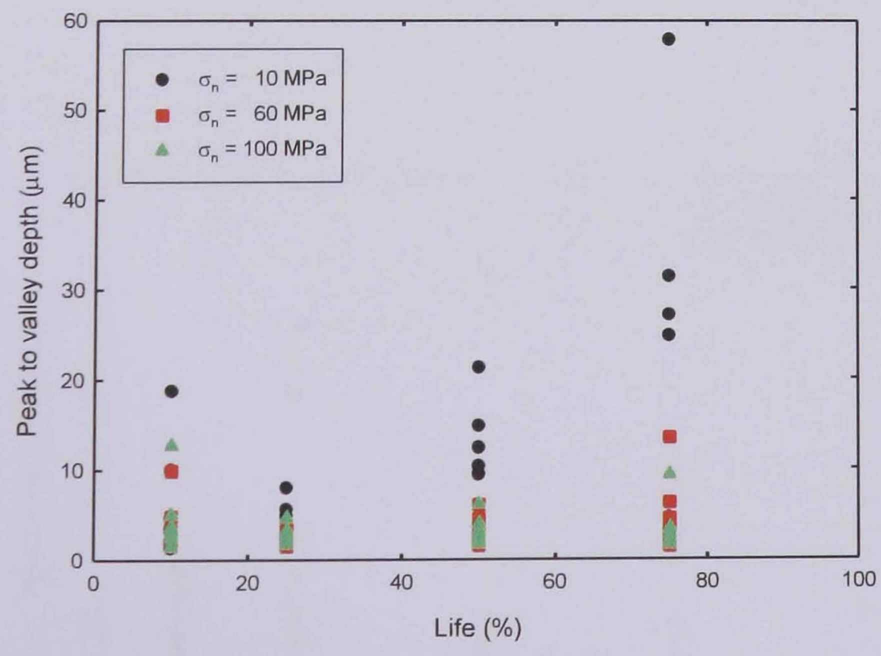
Measurements of the total peak to valley depth, h, determined from traces of the fretting scars. A definition of this feature can be found in Figure 4.44.

K.1 PEAK TO VALLEY DEPTH: σ_a = 70 MPa unpeened

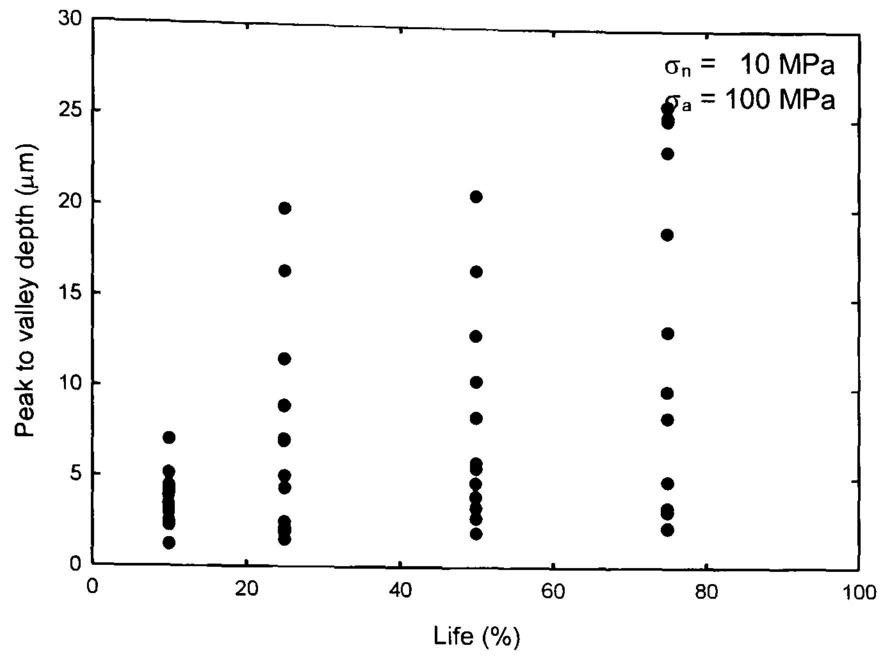


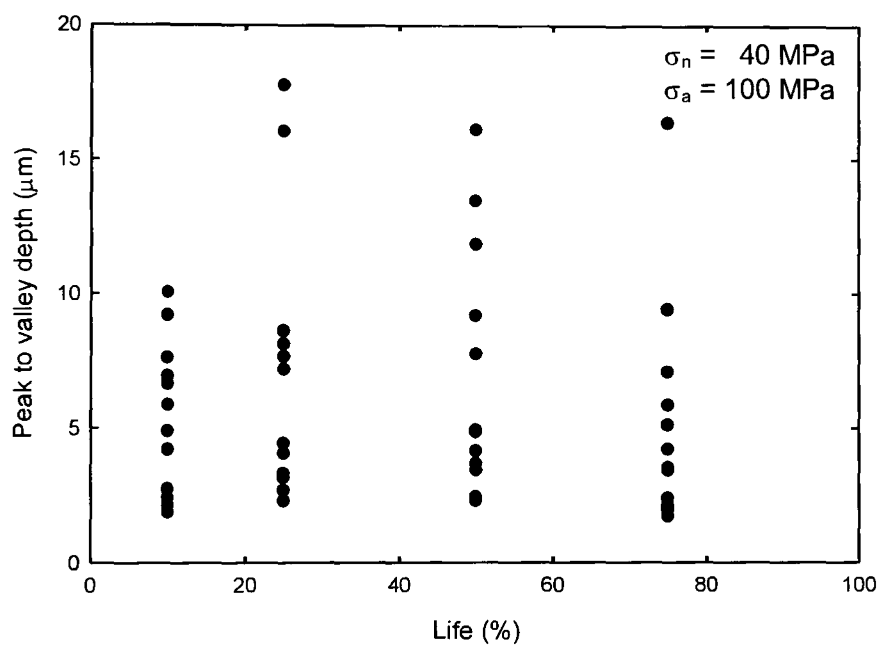

σn = 60 MPa
σa = 70 MPa
Peak to valley depth (μm)
Life (%)
0
2
4
6
8
10
12
14
20
40
60
80
100

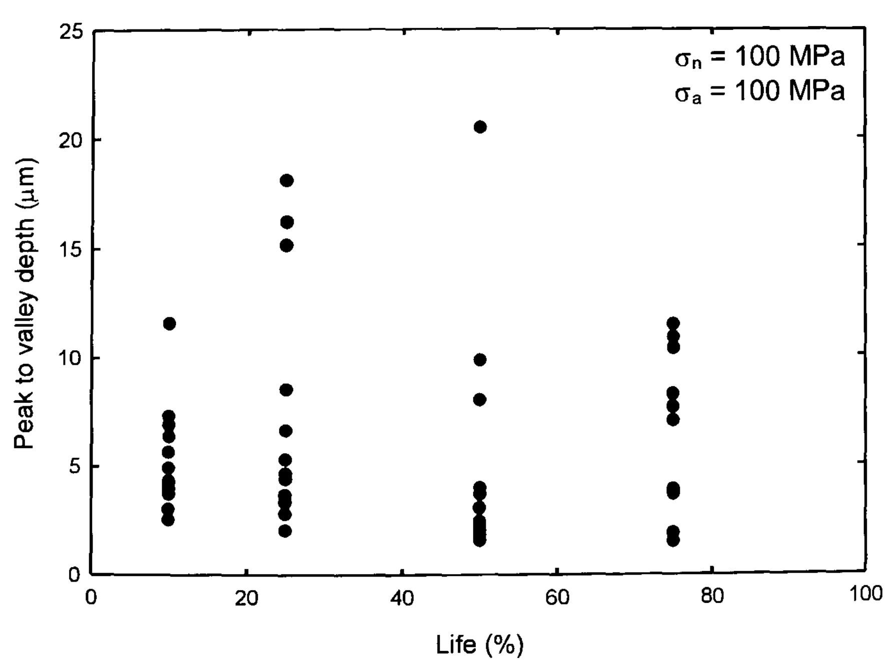

σn = 100 MPa
σa = 70 MPa
Peak to valley depth (μm)
Life (%)
0
2
4
6
8
10
12
14
20
40
60
80
100

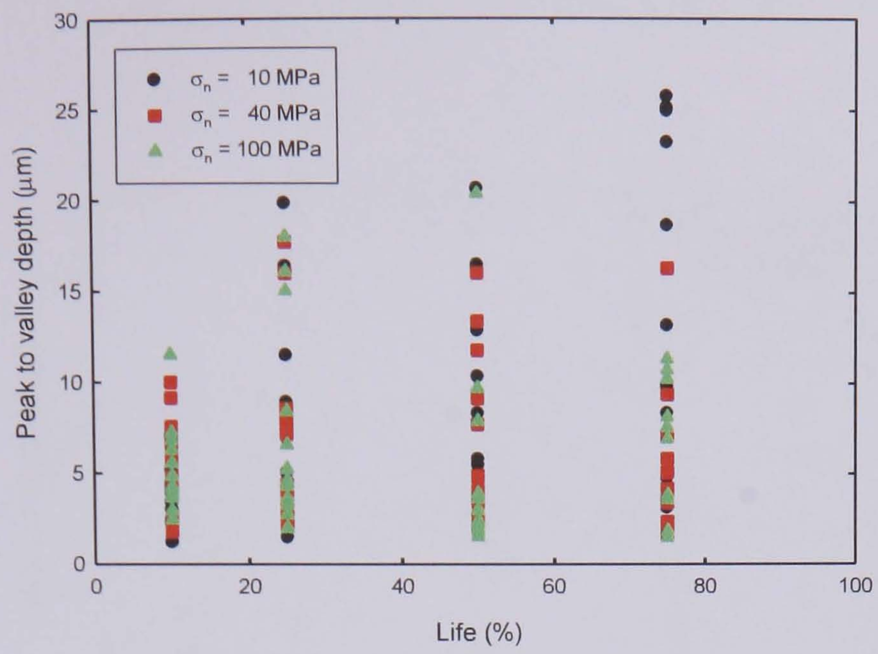

σn = 10 MPa
σn = 60 MPa
σn = 100 MPa
Peak to valley depth (μm)
Life (%)
0
10
20
30
40
50
60
80
100

K.2 PEAK TO VALLEY DEPTH: σ_a = 100 MPa unpeened

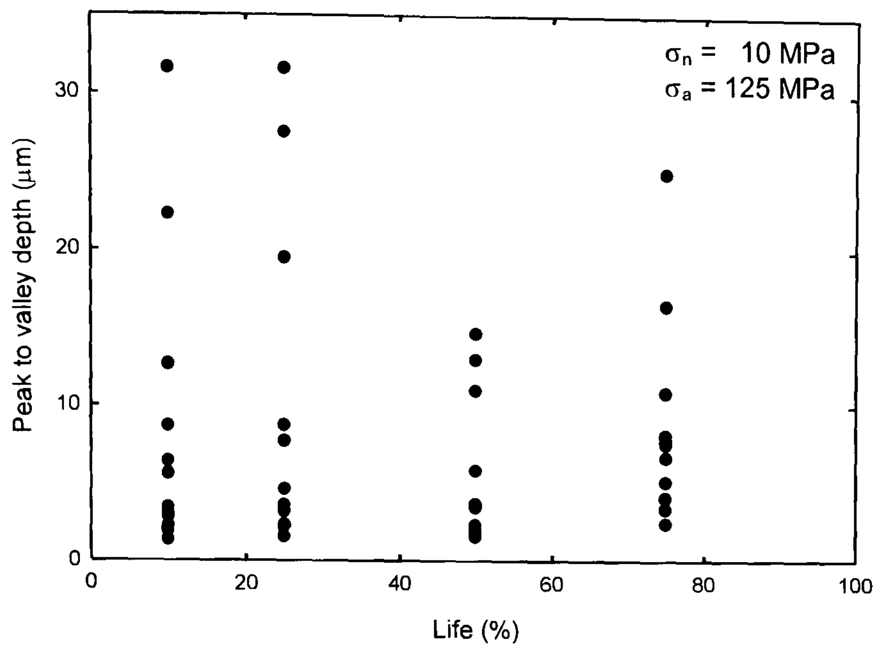


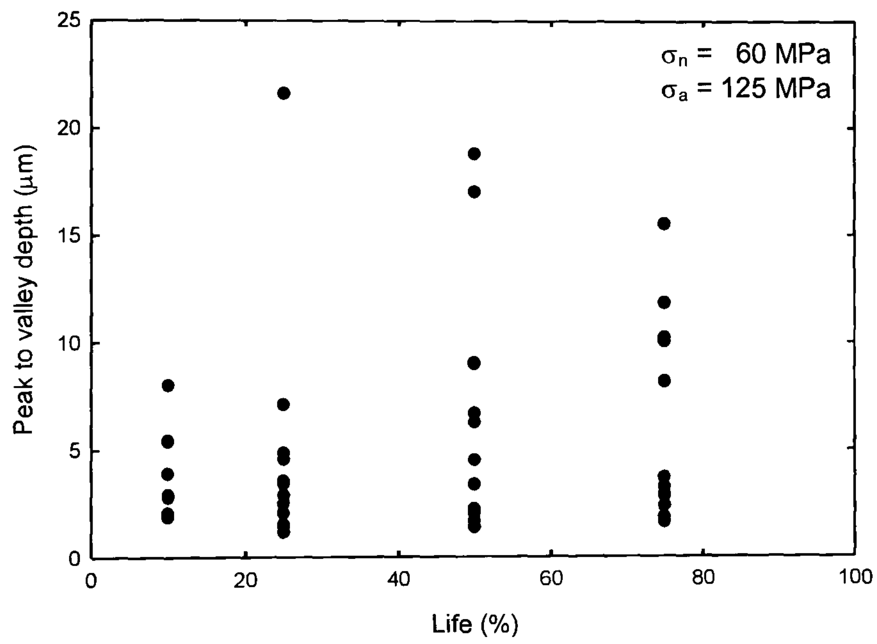


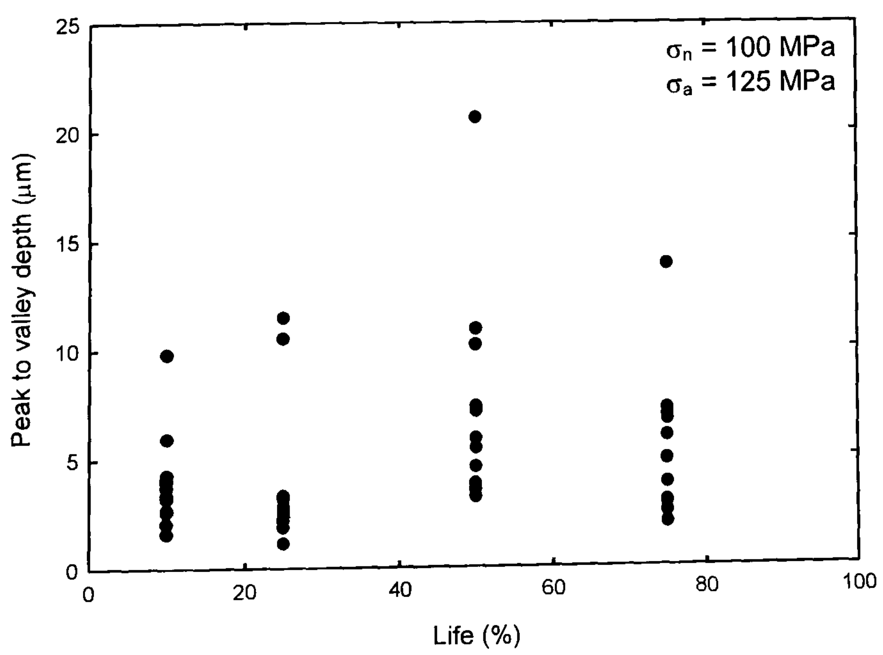


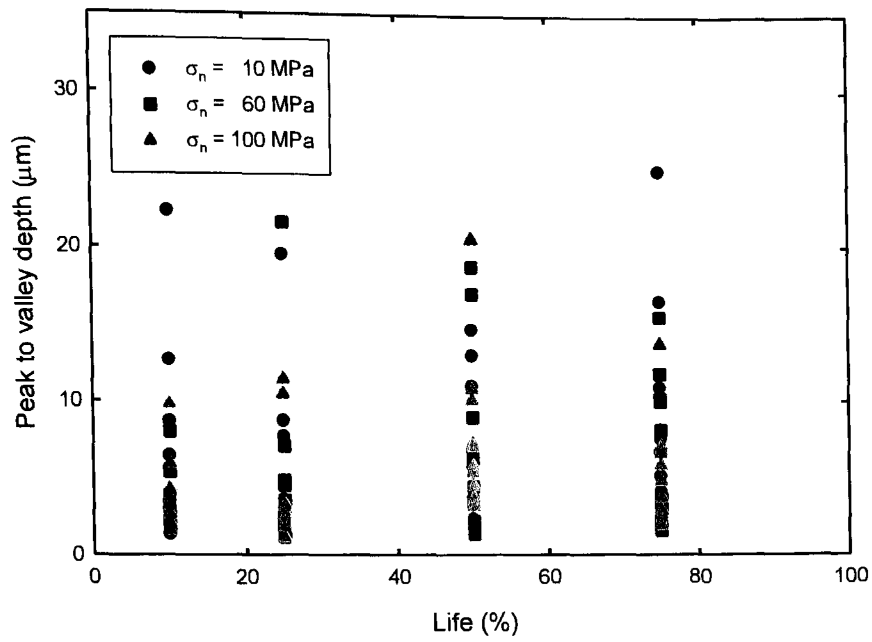

σn = 10 MPa
σn = 40 MPa
σn = 100 MPa
Peak to valley depth (μm)
Life (%)
0
5
10
15
20
25
30
0
20
40
60
80
100

K.3 PEAK TO VALLEY DEPTH: σ_a = 125 MPa unpeened



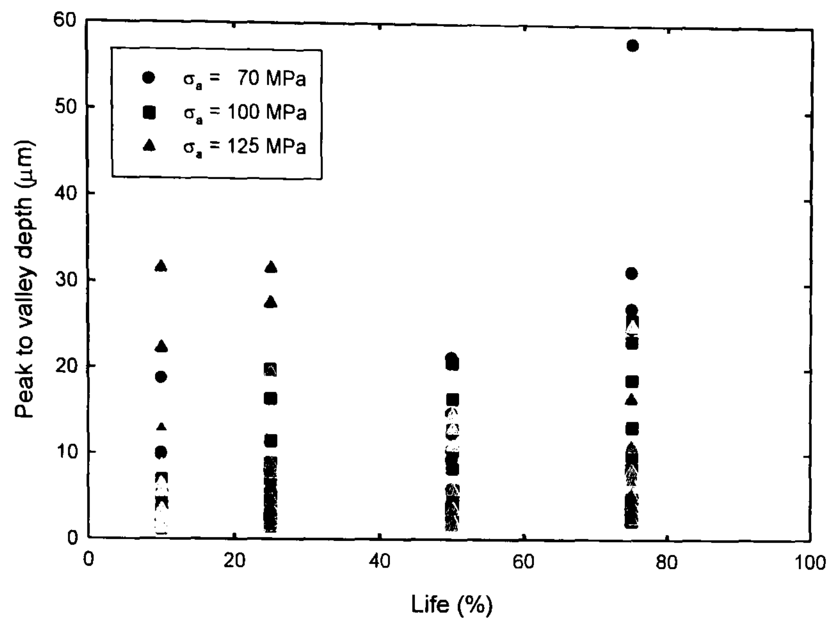




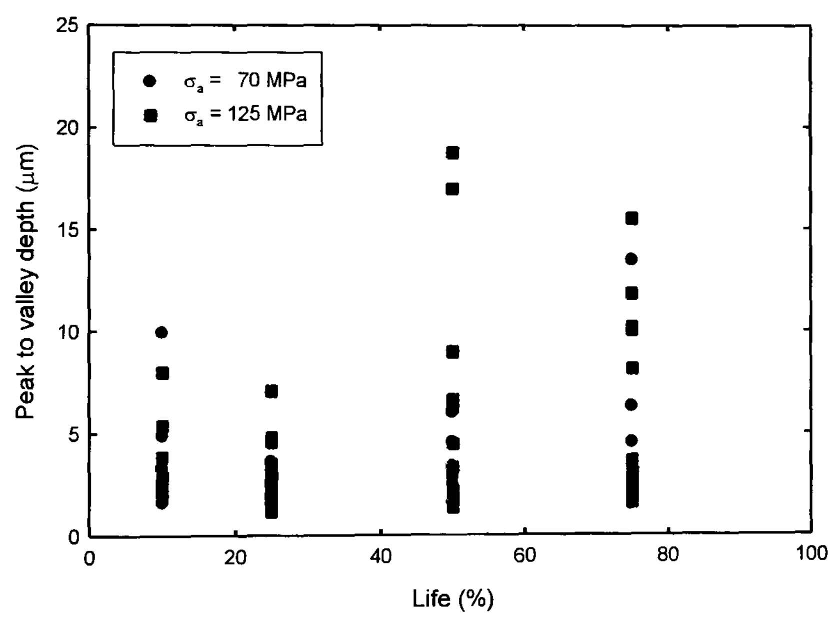

σn = 10 MPa
σn = 60 MPa
σn = 100 MPa
Peak to valley depth (μm)
Life (%)
0
10
20
30
0
20
40
60
80
100

K.4 PEAK TO VALLEY DEPTH: Unpeened

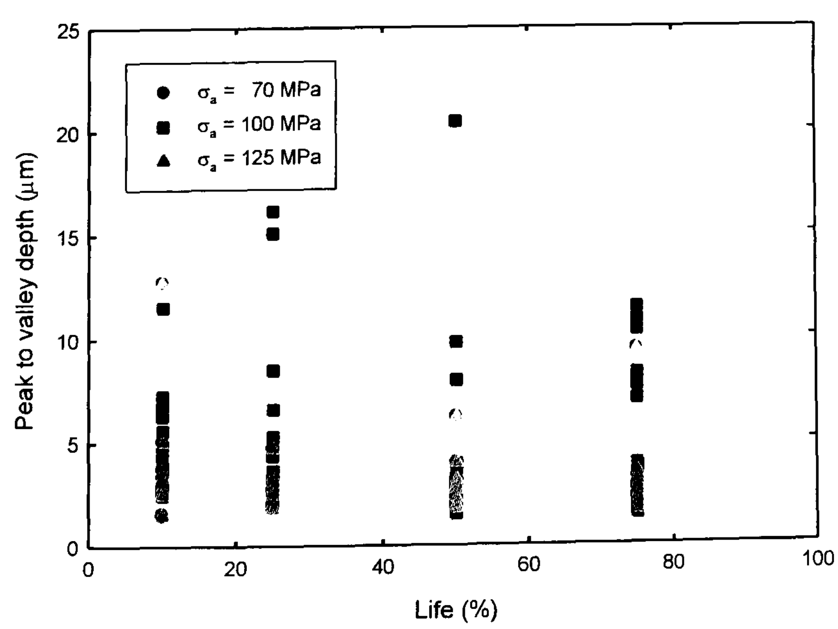
σ_n = 10 MPa:



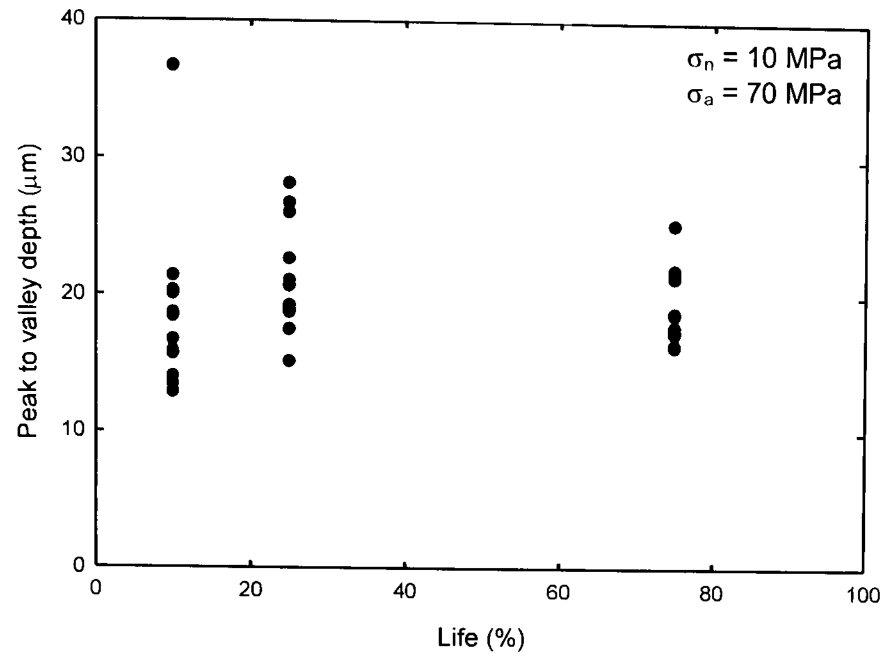
σ_n = 60 MPa:

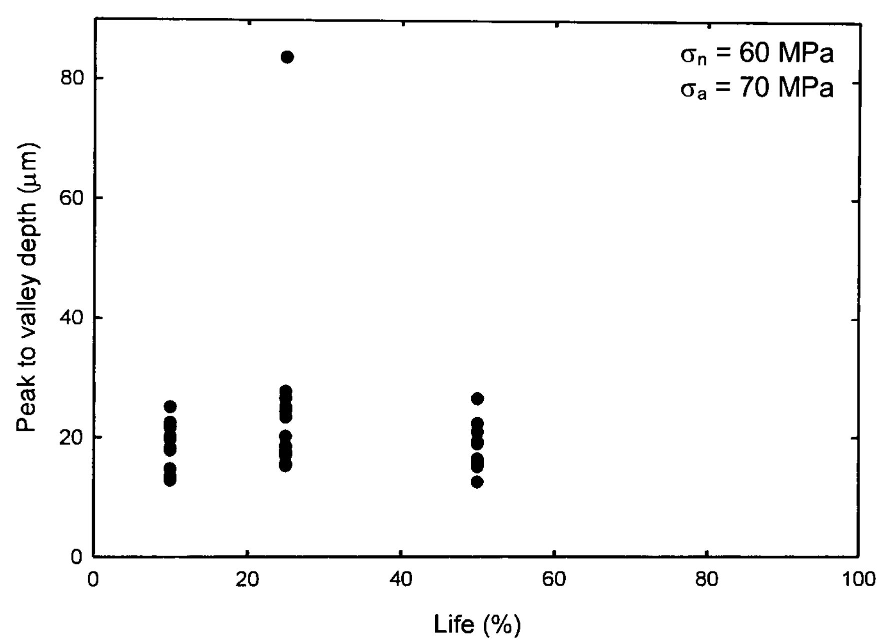


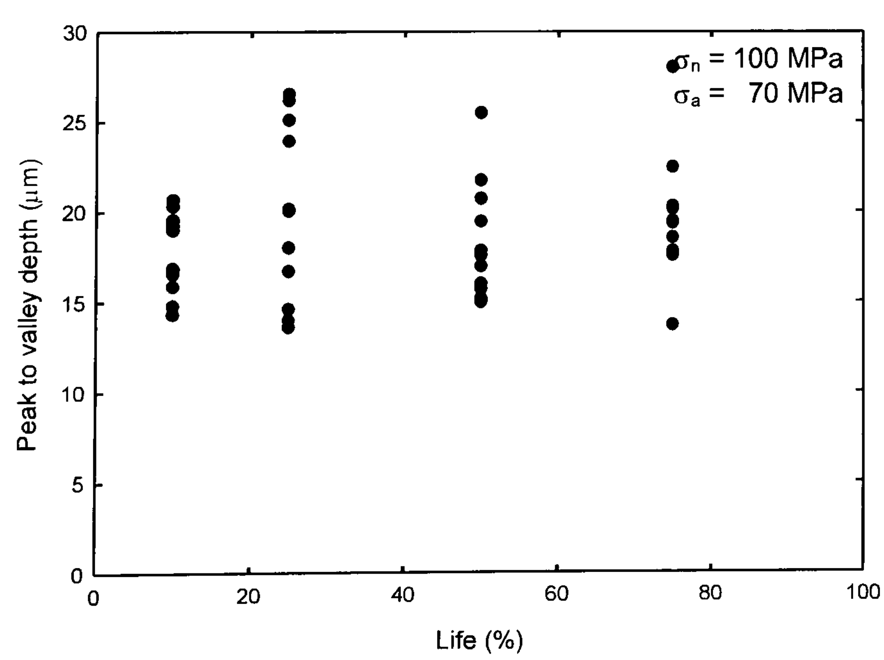
σ_n = 100 MPa:

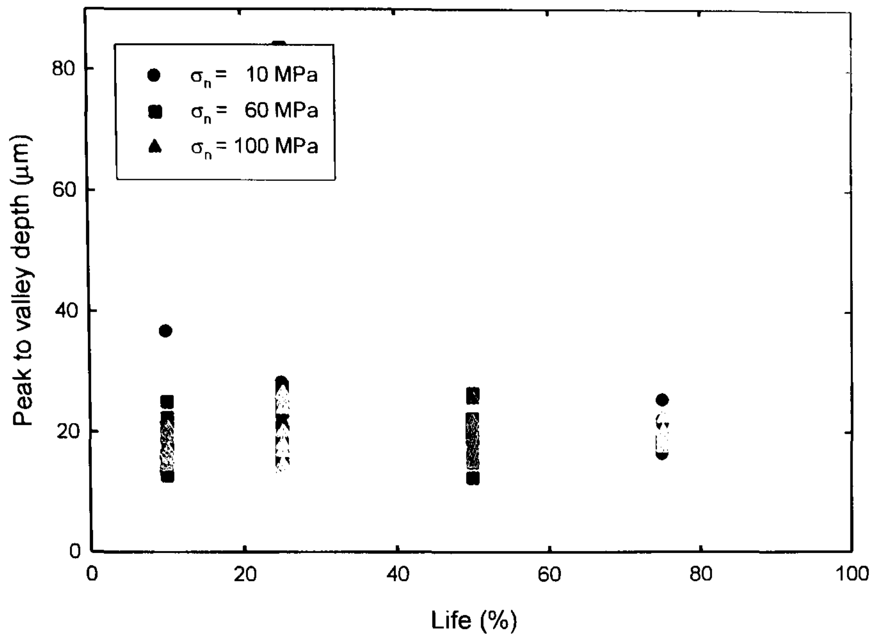


K.5 PEAK TO VALLEY DEPTH: σ_a = 70 MPa peened



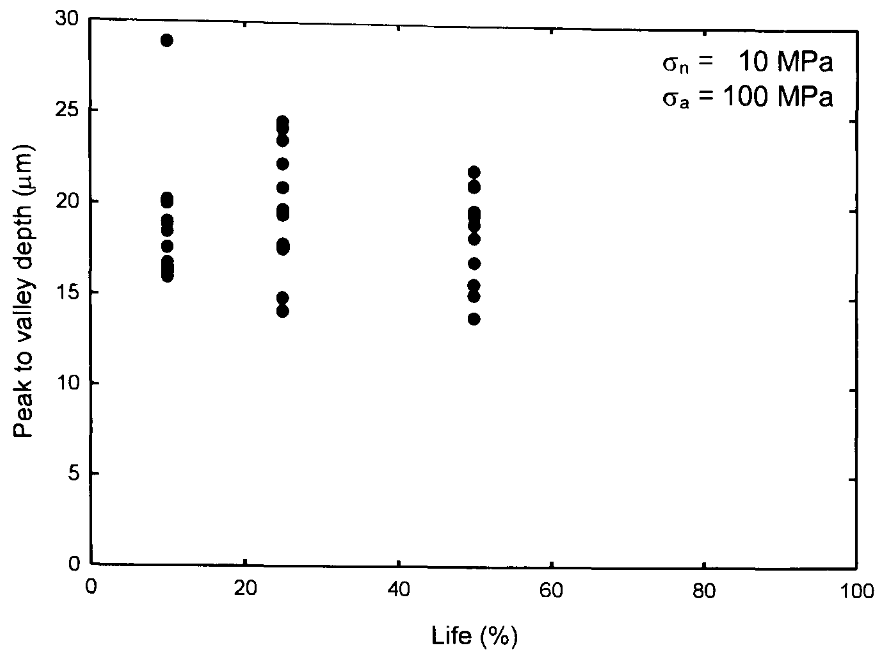


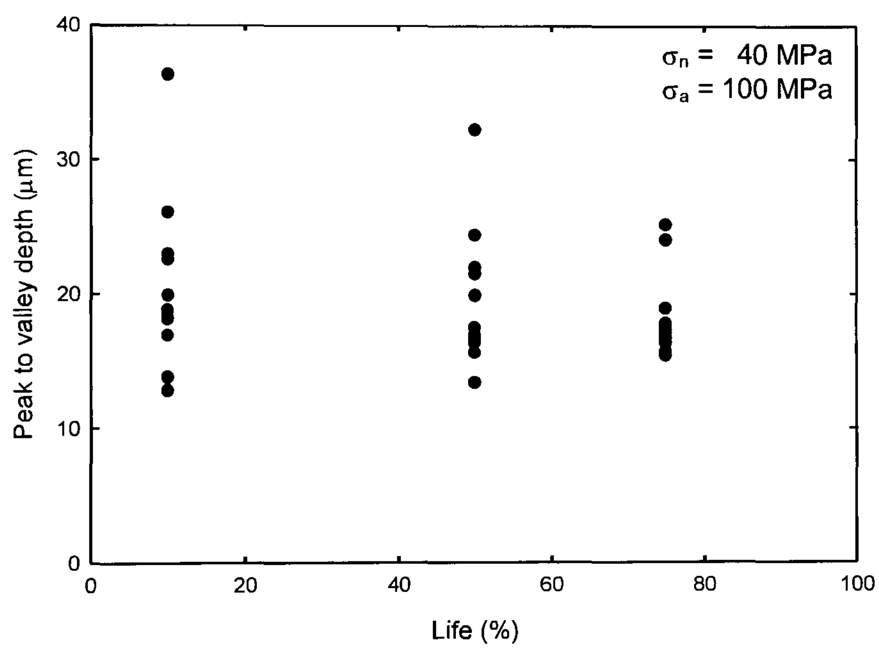


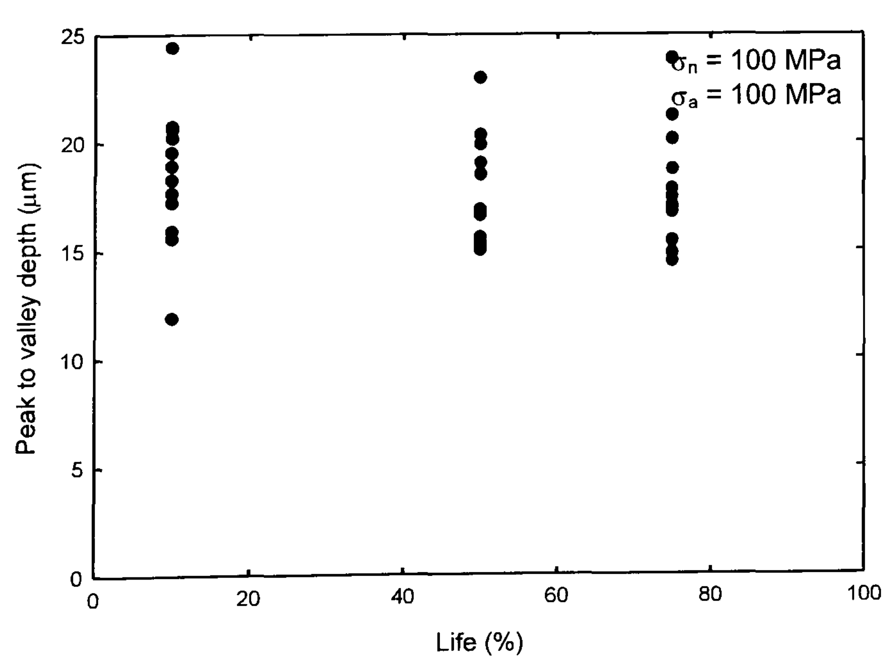


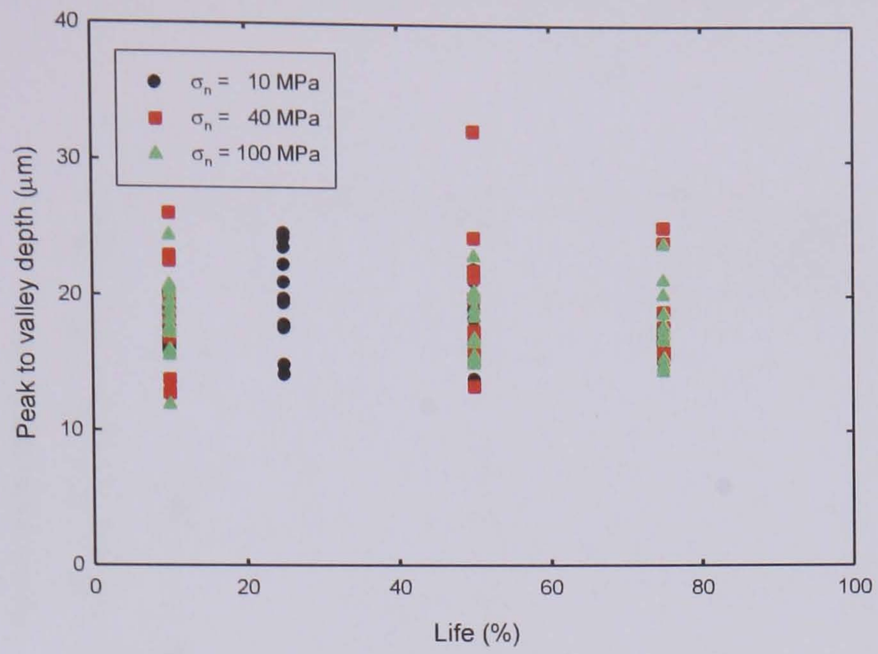
Peak to valley depth (μm)
Life (%)
σn = 10 MPa
σn = 60 MPa
σn = 100 MPa
0
20
40
60
80
100

K.6 PEAK TO VALLEY DEPTH: σ_a = 100 MPa peened



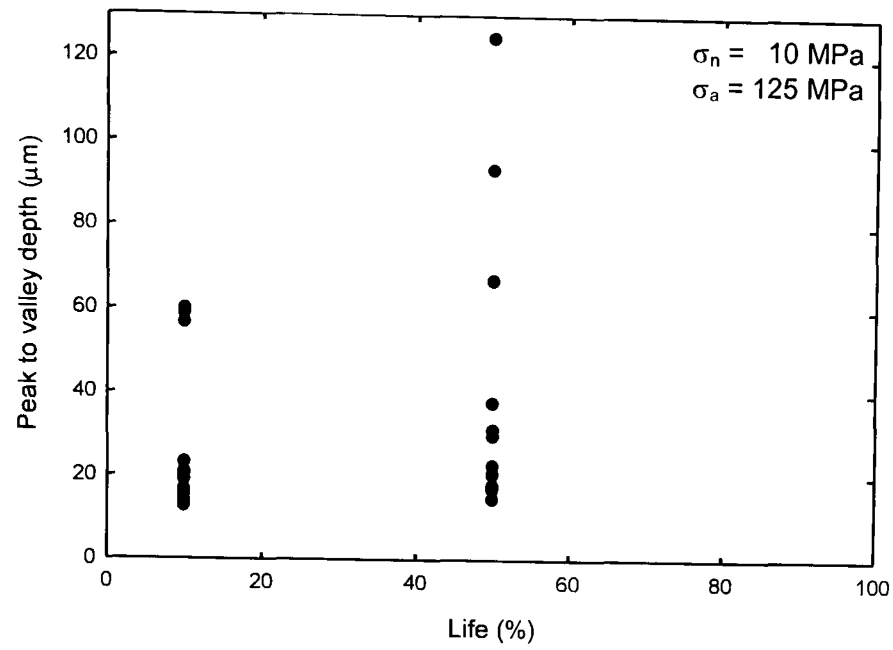


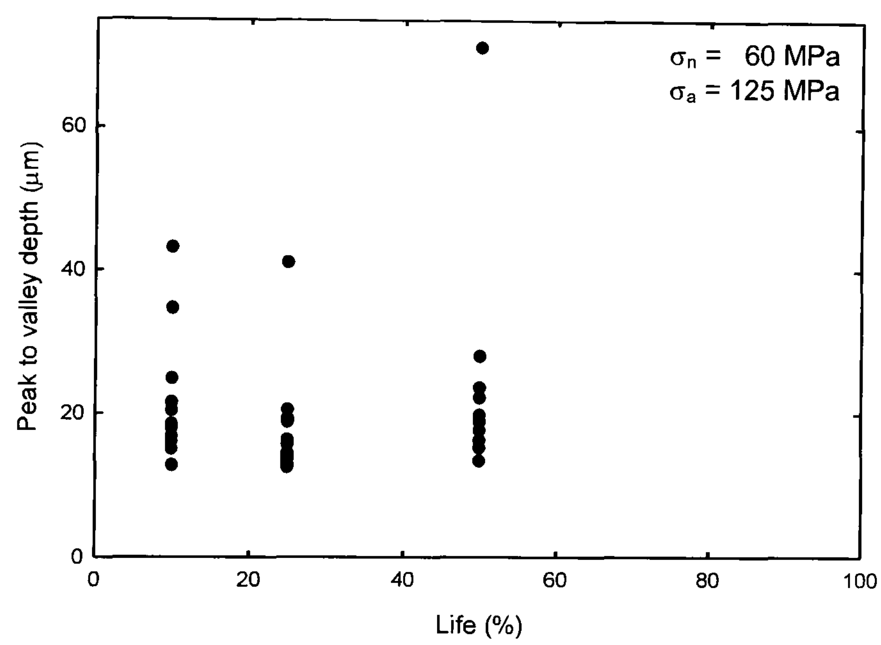


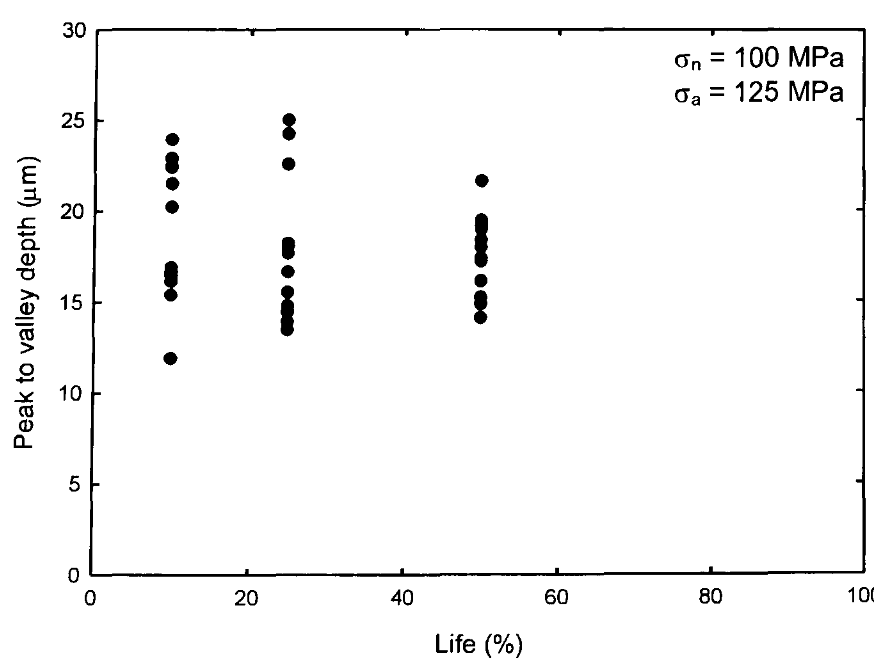


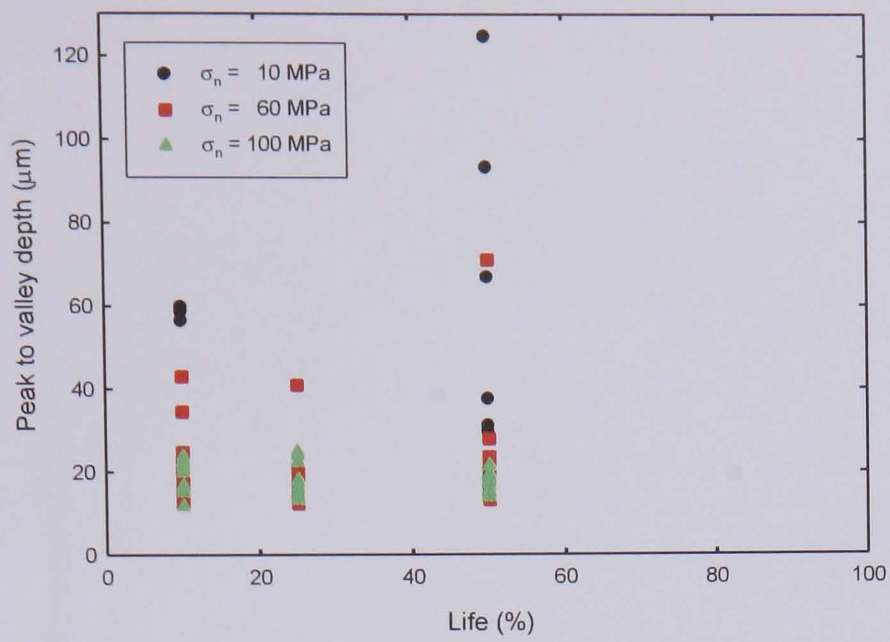
σn = 10 MPa
σn = 40 MPa
σn = 100 MPa
Peak to valley depth (μm)
Life (%)

K.7 PEAK TO VALLEY DEPTH: σ_a = 125 MPa peened





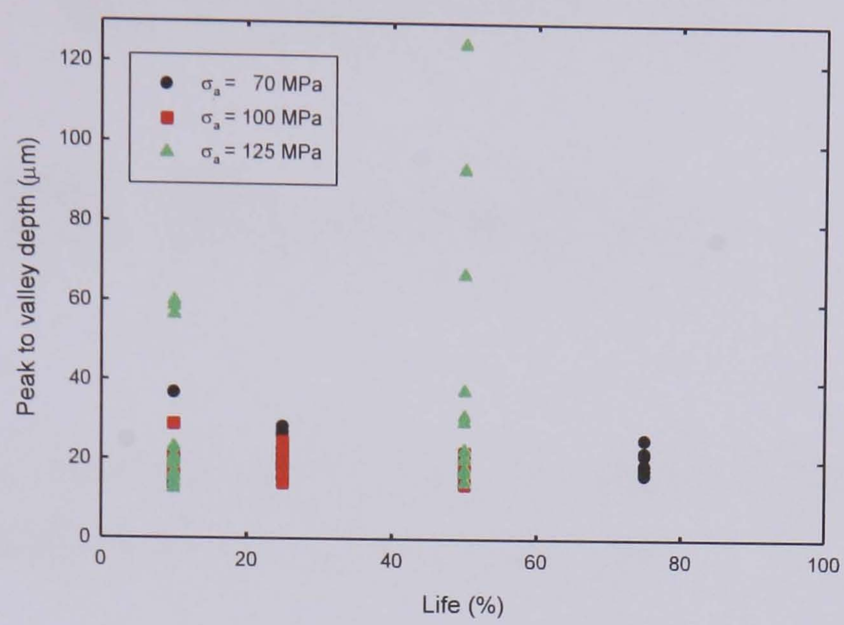




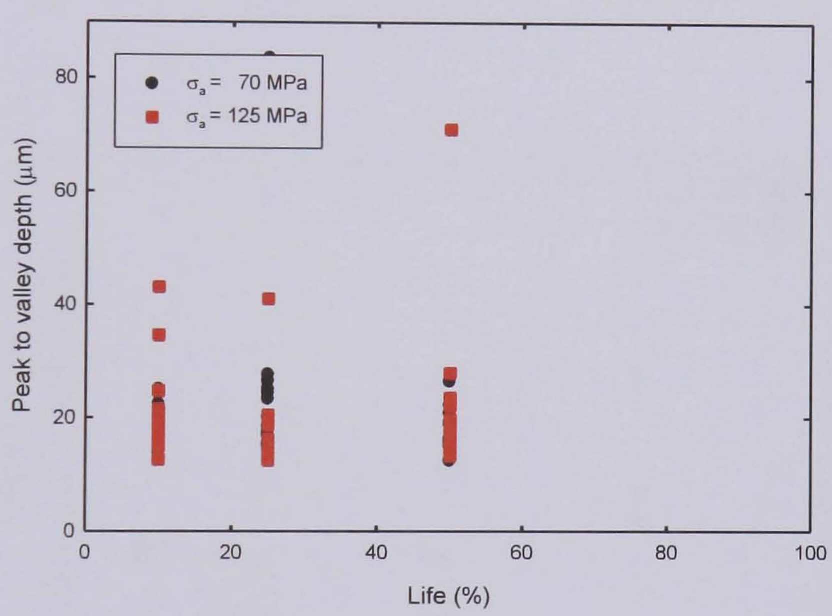
Peak to valley depth (μm)
Life (%)
σn = 10 MPa
σn = 60 MPa
σn = 100 MPa
0
20
40
60
80
100
120
0
20
40
60
80
100

K.8 PEAK TO VALLEY DEPTH: Peened

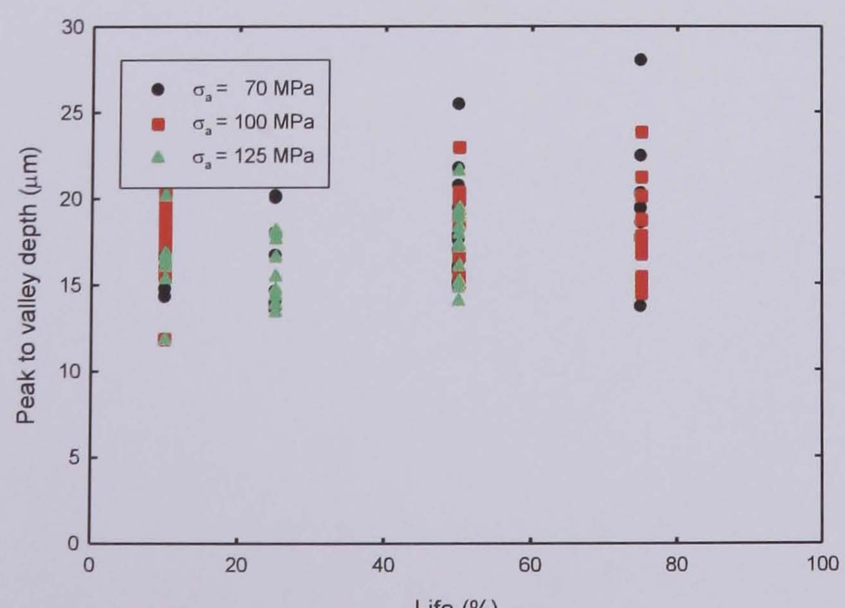
σ_n = 10 MPa:



σ_n = 60 MPa:



σ_n = 100 MPa:

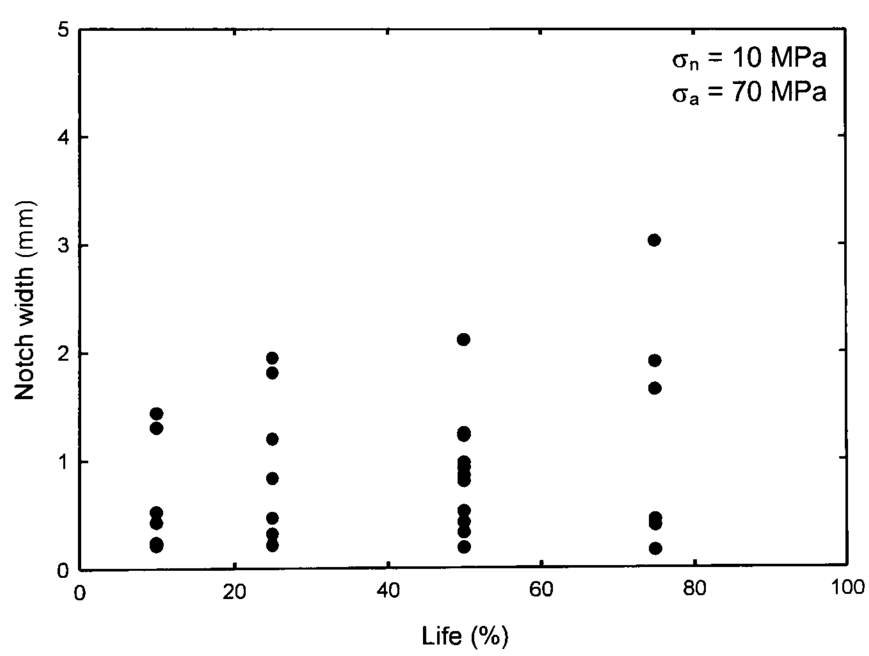


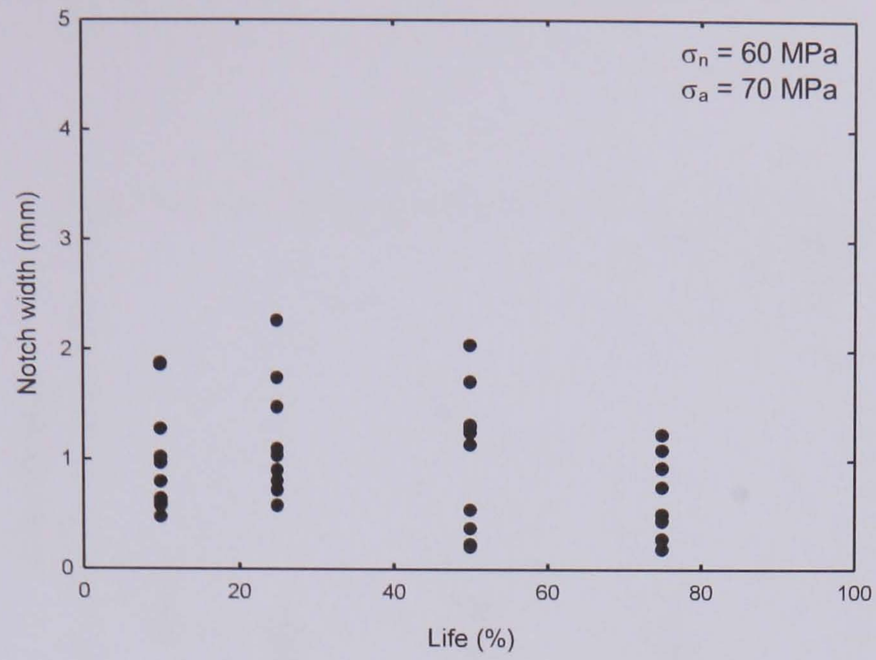
APPENDIX L

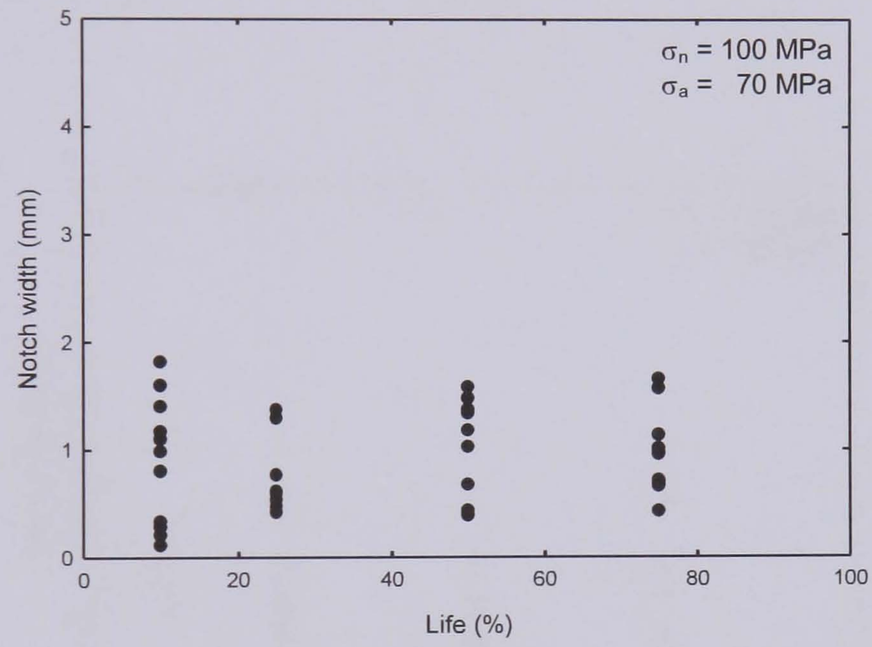
RESULTS: SCAR WIDTH

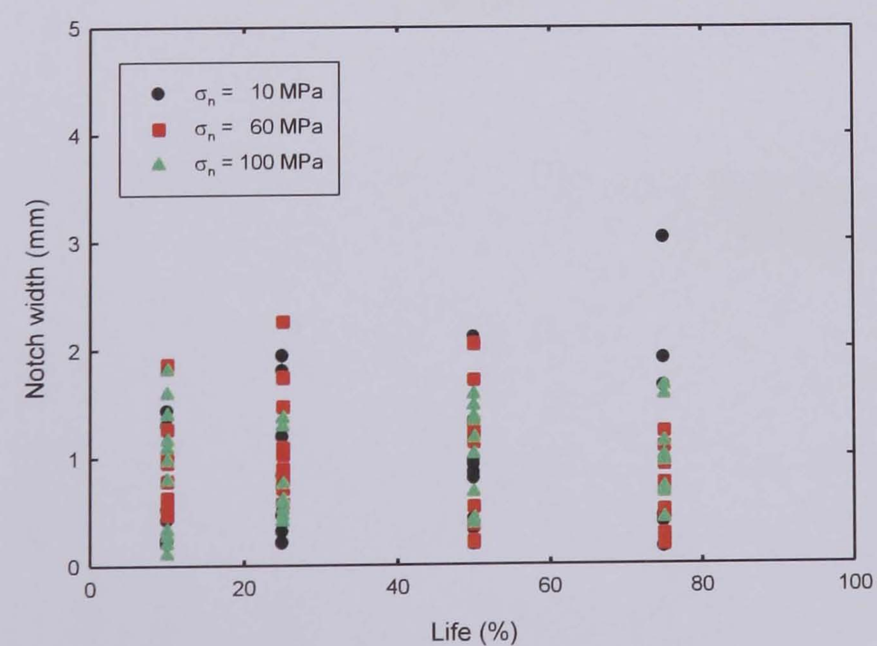
Measurements of width, w, determined from traces of the fretting scars. A definition of this feature can be found in Figure 4.44.

L.1 SCAR WIDTH: σ_a = 70 MPa unpeened

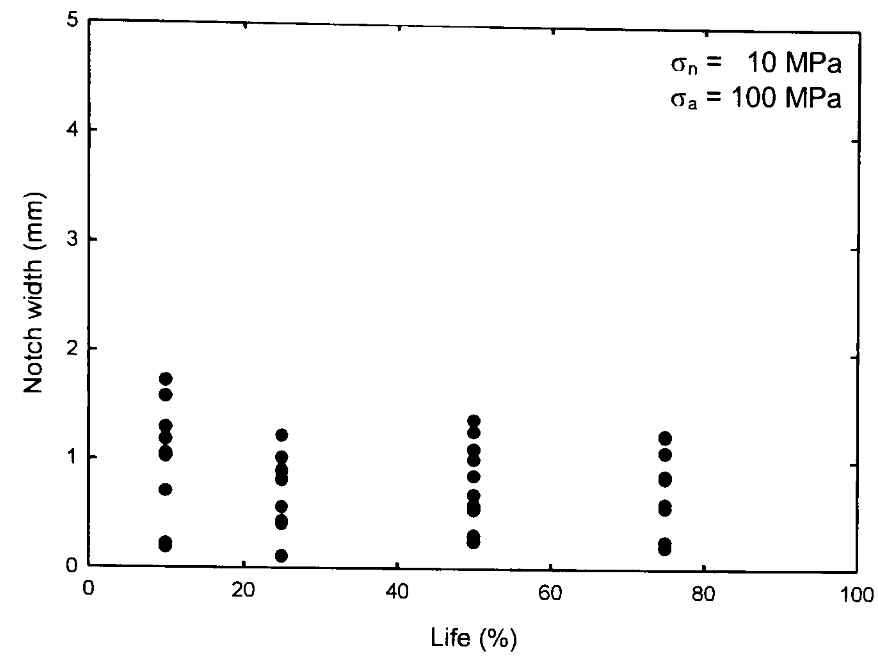


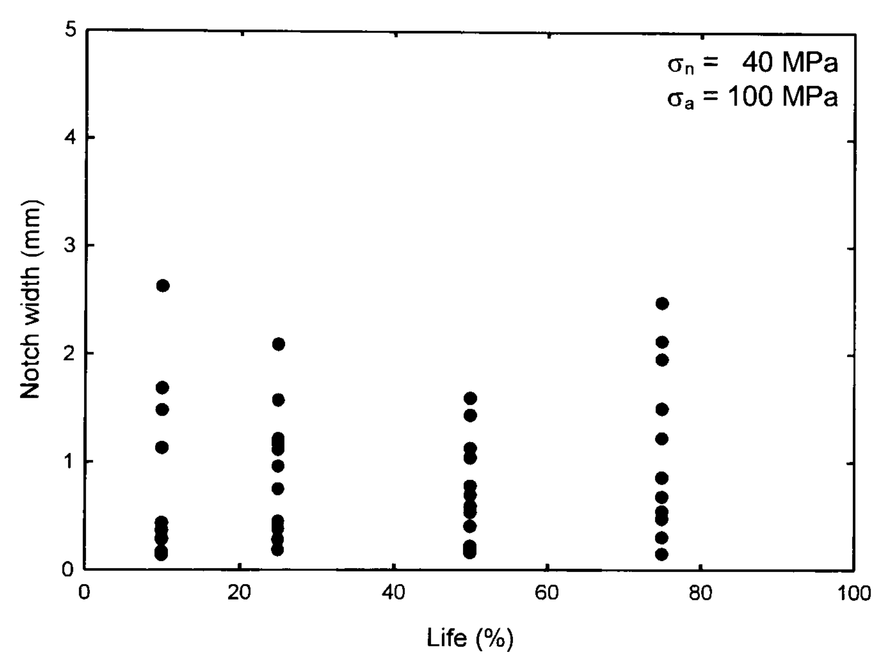

σn = 60 MPa
σa = 70 MPa
Notch width (mm)
Life (%)

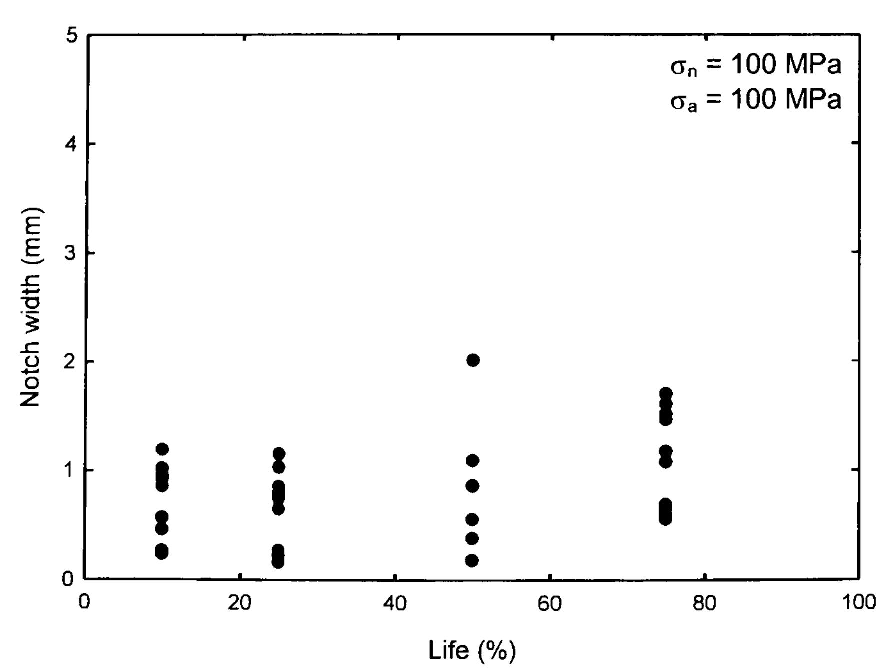

σn = 100 MPa
σa = 70 MPa
Notch width (mm)
Life (%)

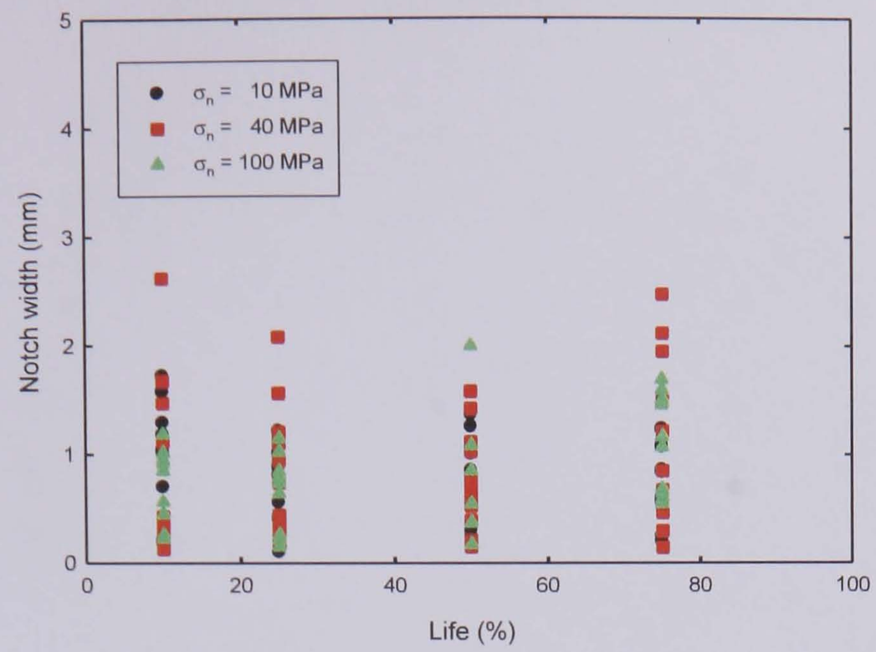

σn = 10 MPa
σn = 60 MPa
σn = 100 MPa
Notch width (mm)
Life (%)

L.2 SCAR WIDTH: σ_a = 100 MPa unpeened

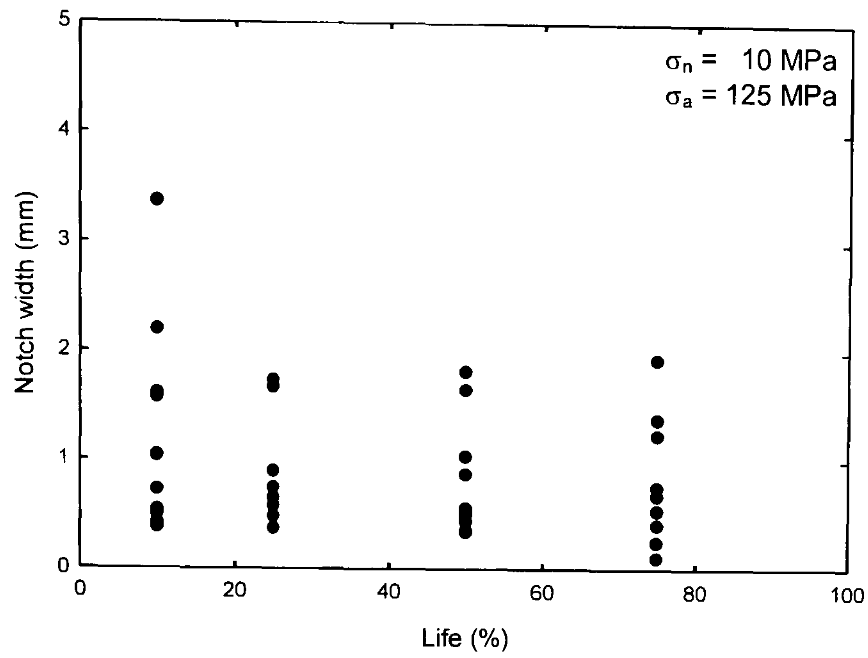


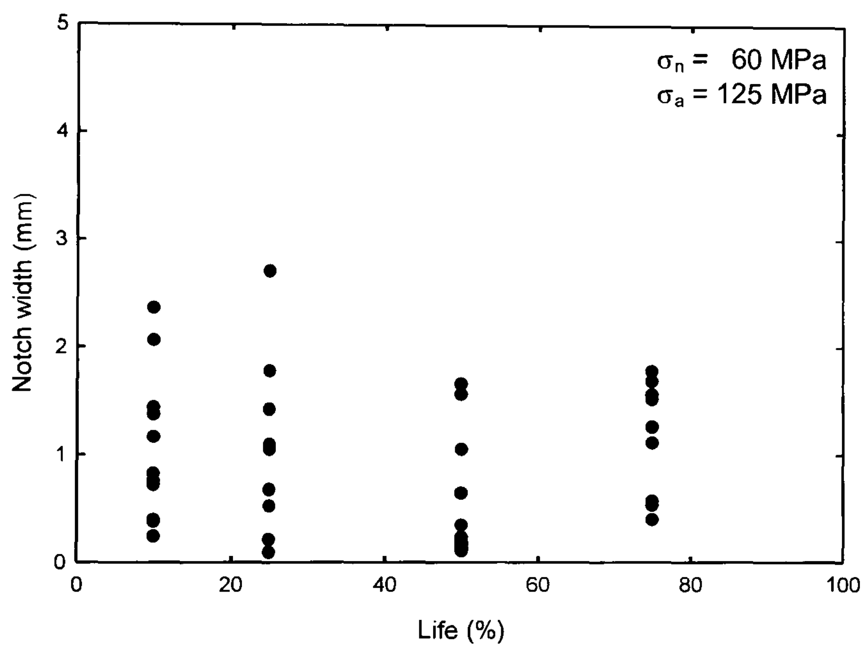


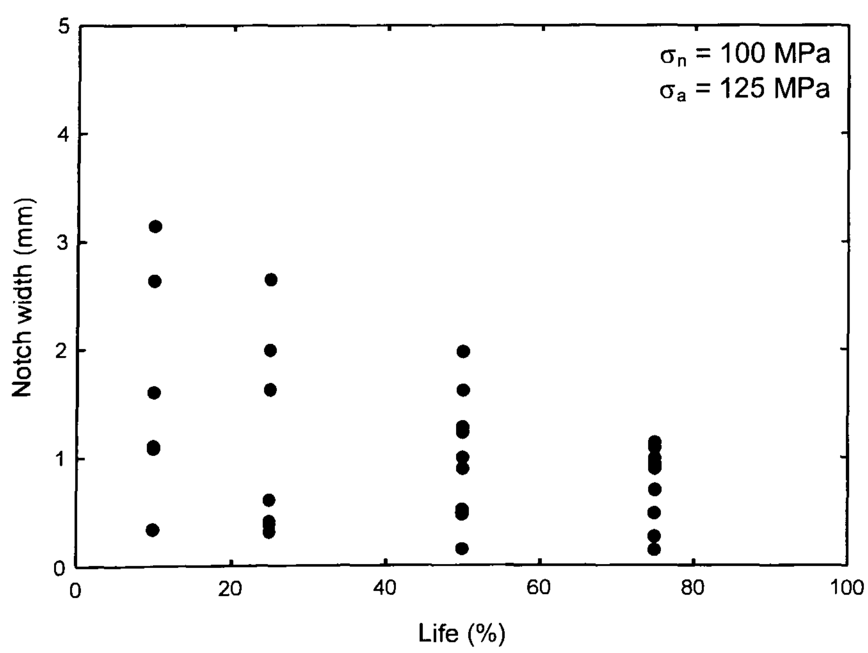


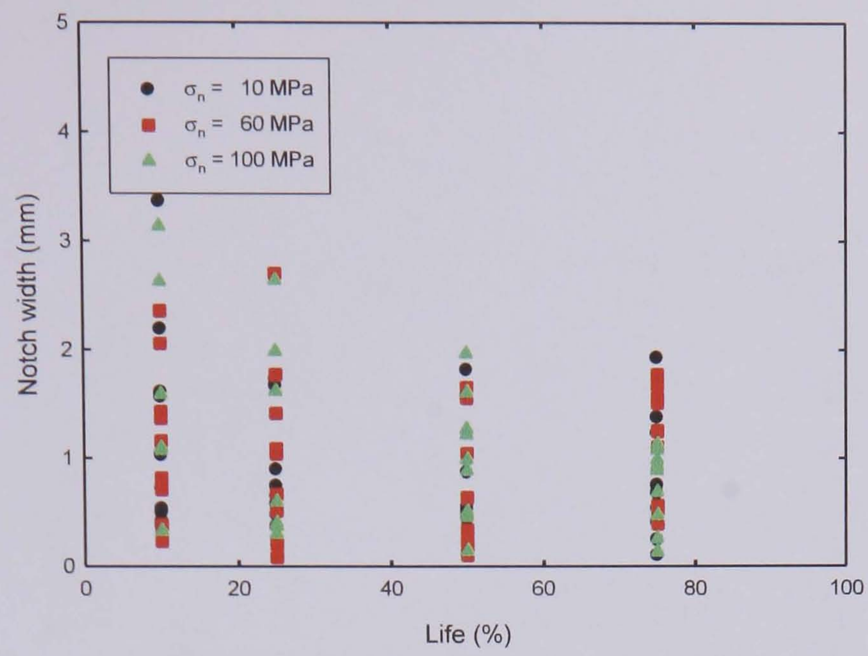

σn = 10 MPa
σn = 40 MPa
σn = 100 MPa
Notch width (mm)
Life (%)
0
1
2
3
4
5
0
20
40
60
80
100

L.3 SCAR WIDTH: σ_a = 125 MPa unpeened





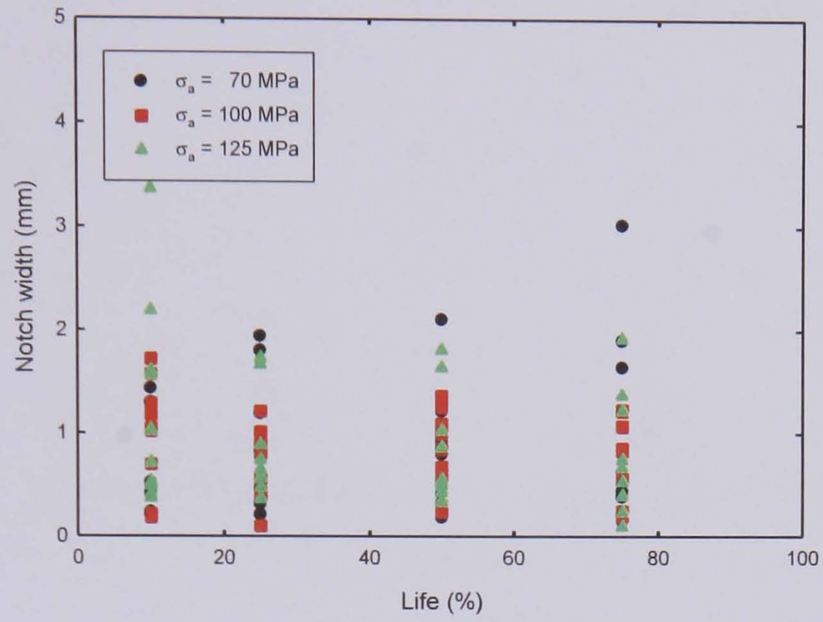




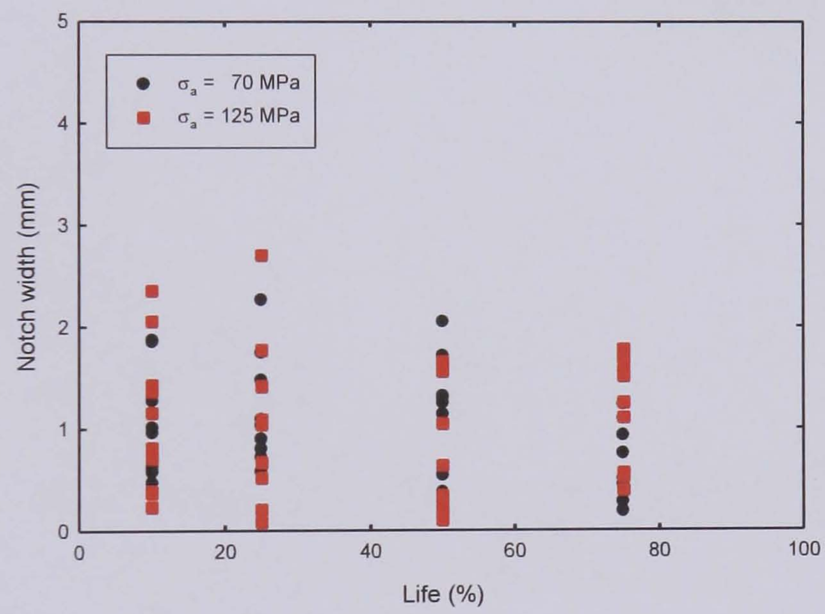
σ_n = 10 MPa
σ_n = 60 MPa
σ_n = 100 MPa
Notch width (mm)
Life (%)
0
1
2
3
4
5
0
20
40
60
80
100

L.4 SCAR WIDTH: Unpeened

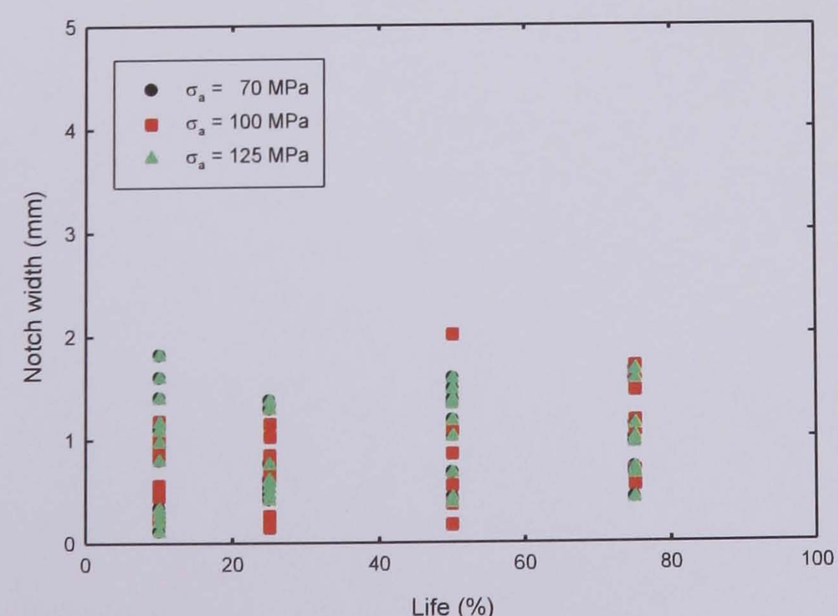
σ_n = 10 MPa:



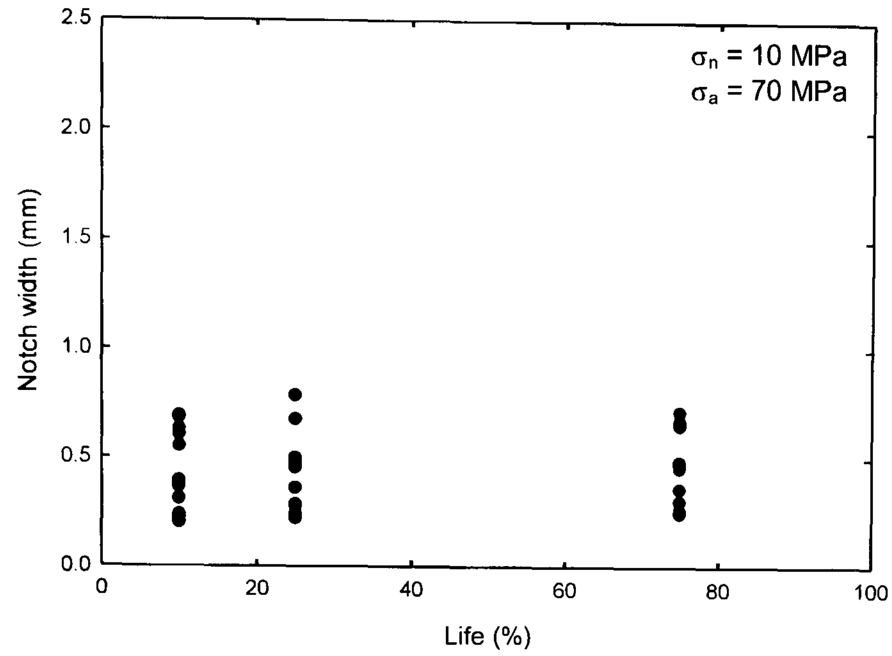
σ_n = 60 MPa:

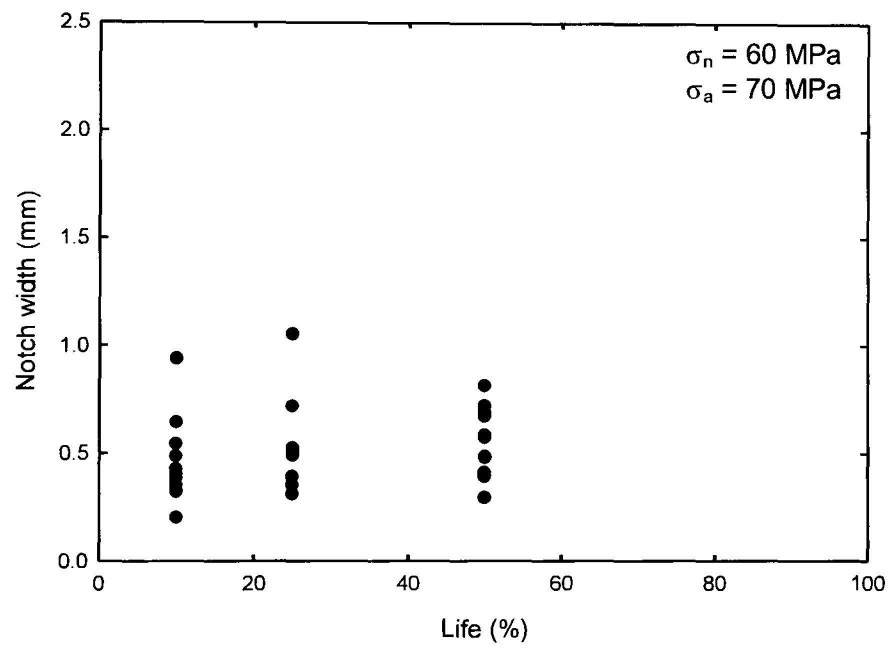


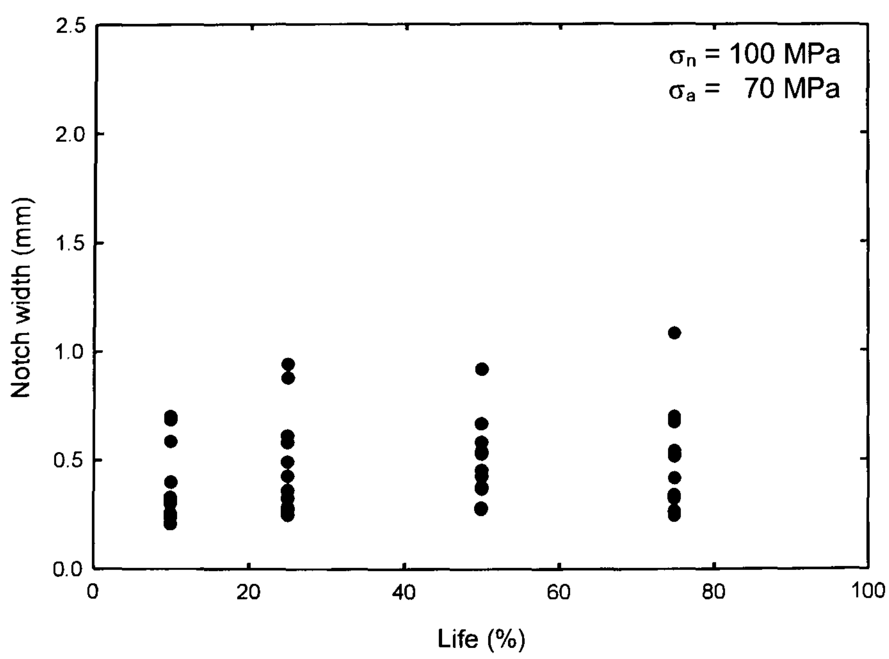
σ_n = 100 MPa:

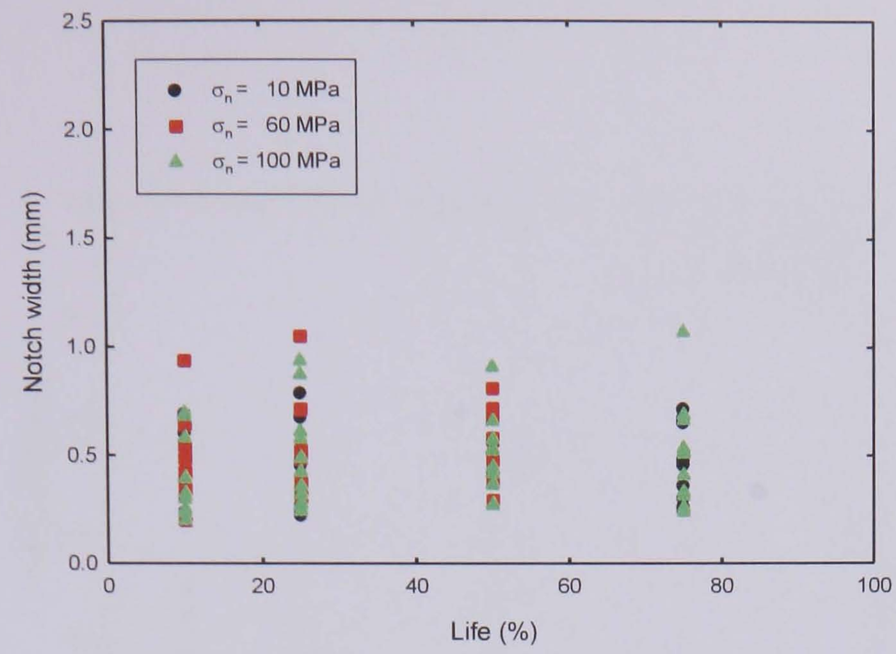


L.5 SCAR WIDTH: σ_a = 70 MPa peened



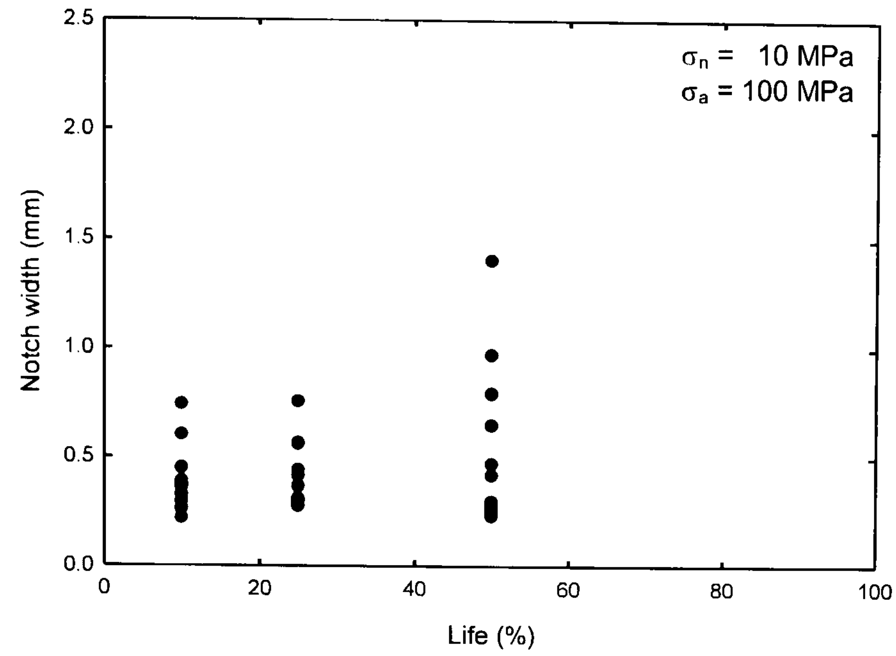


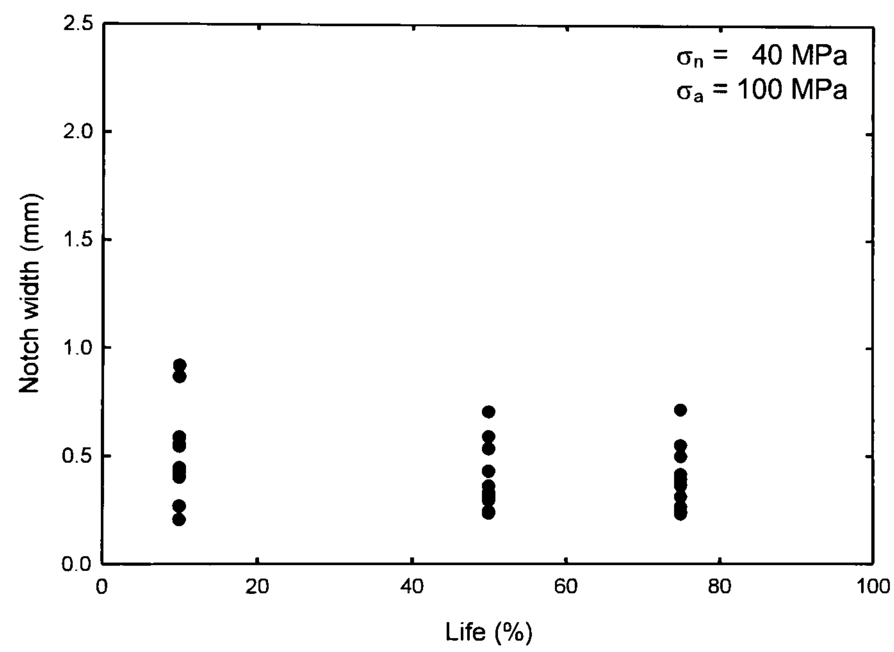


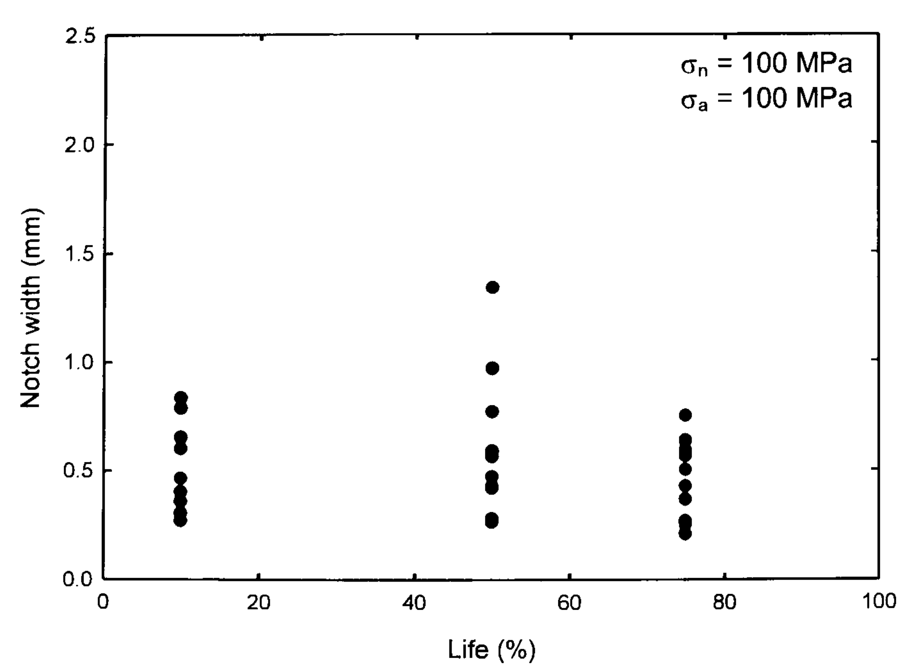


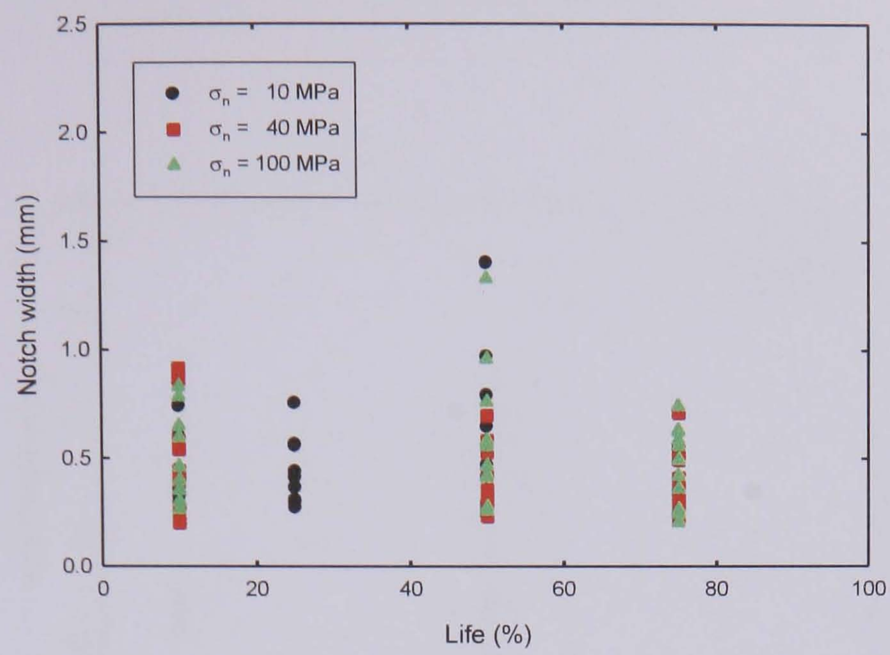
σn = 10 MPa
σn = 60 MPa
σn = 100 MPa
Notch width (mm)
Life (%)

L.6 SCAR WIDTH: σ_a = 100 MPa peened



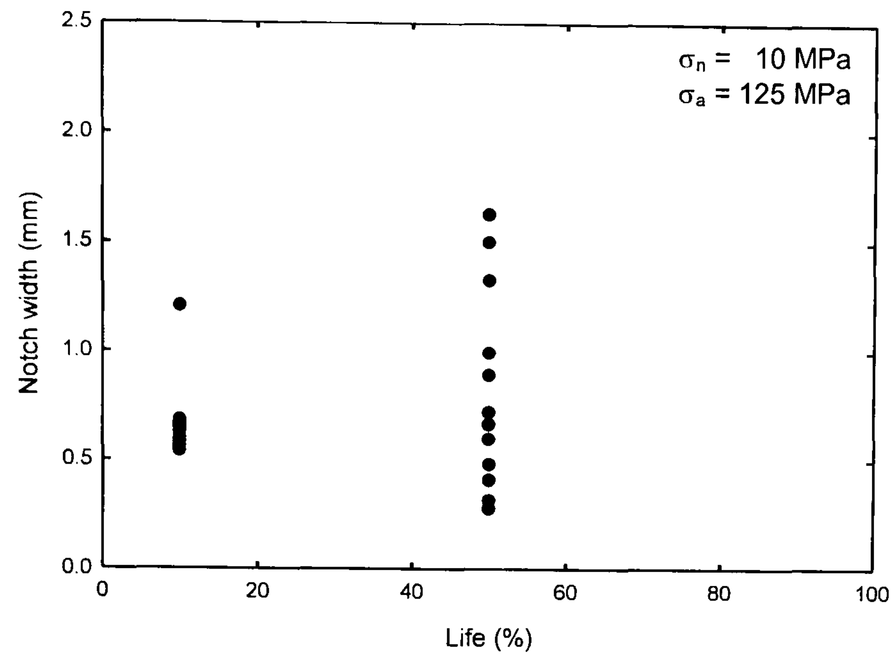


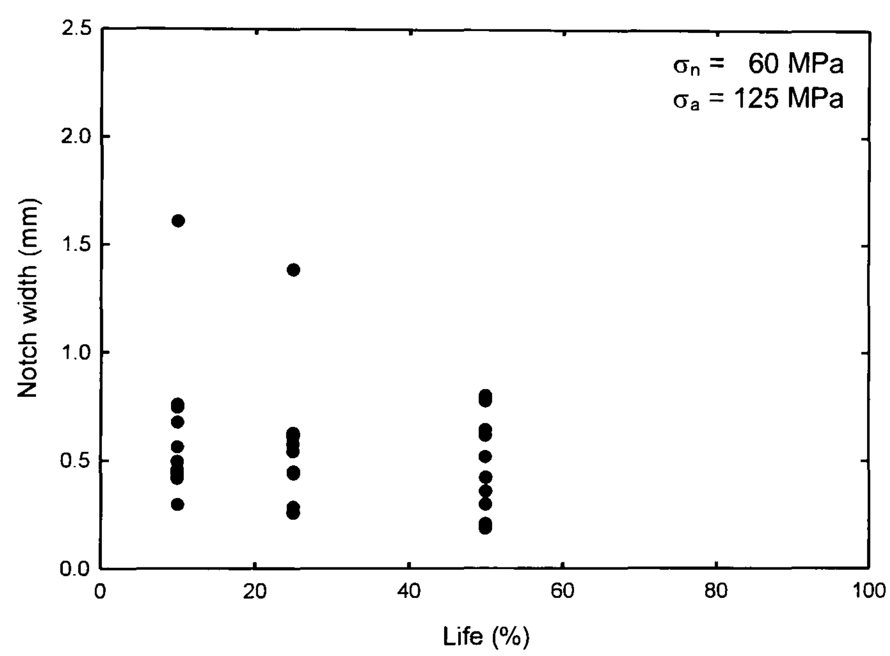


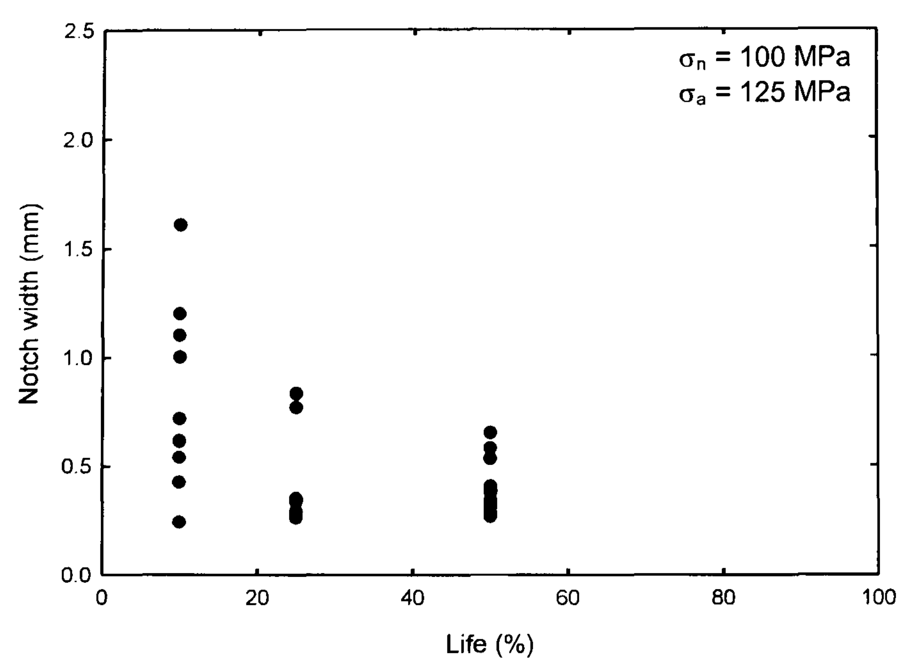


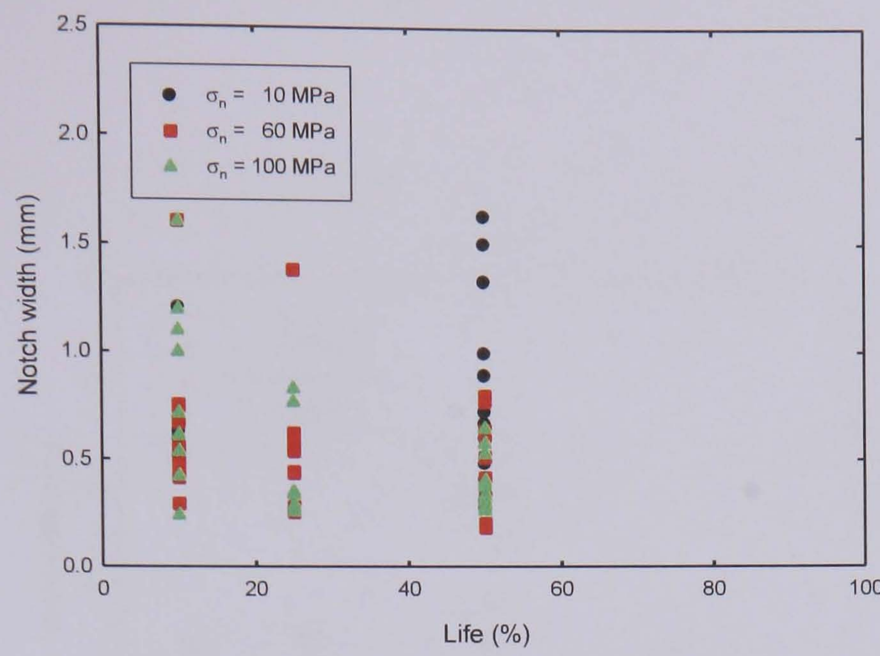
σn = 10 MPa
σn = 40 MPa
σn = 100 MPa
Notch width (mm)
Life (%)
0.0
0.5
1.0
1.5
2.0
2.5
0
20
40
60
80
100

L.7 SCAR WIDTH: σ_a = 125 MPa peened





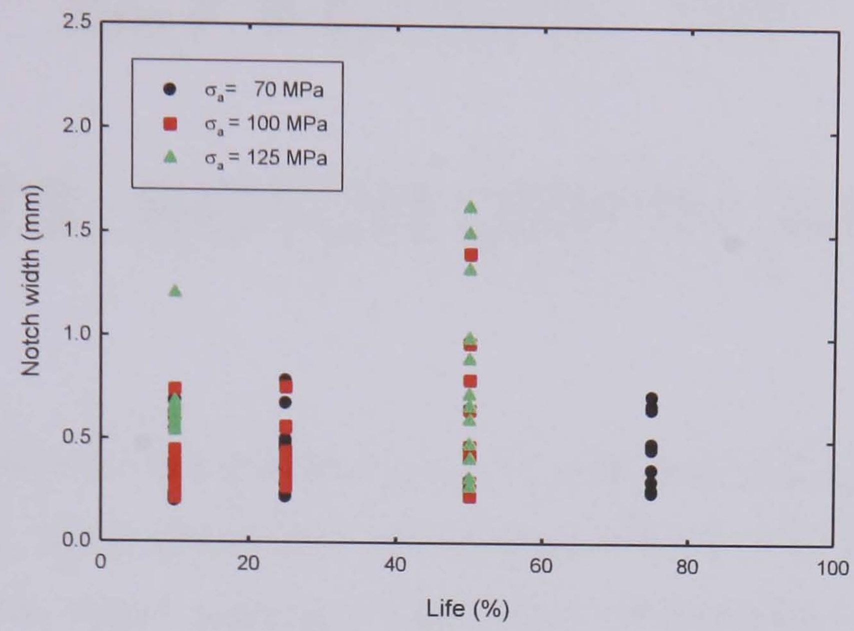




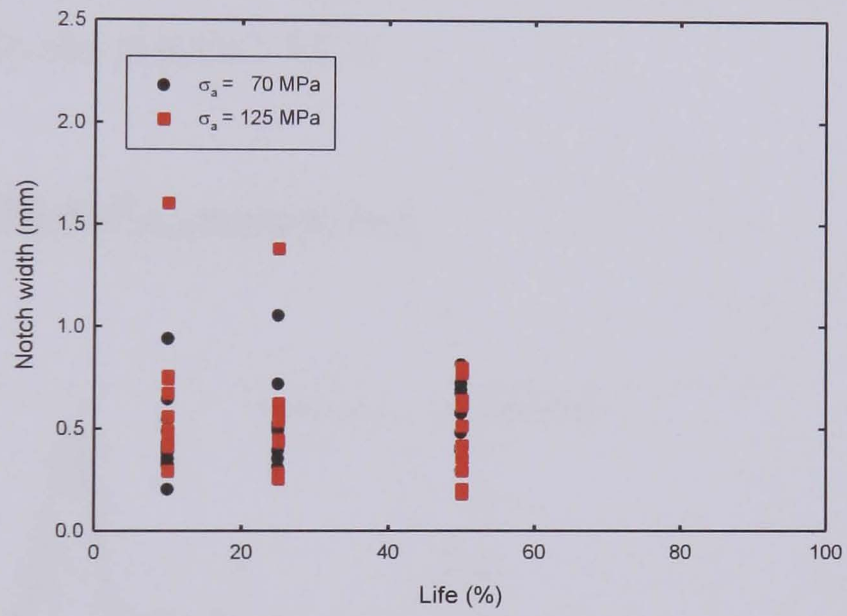
σn = 10 MPa
σn = 60 MPa
σn = 100 MPa
Notch width (mm)
Life (%)
0.0
0.5
1.0
1.5
2.0
2.5
0
20
40
60
80
100

L.8 SCAR WIDTH: Peened

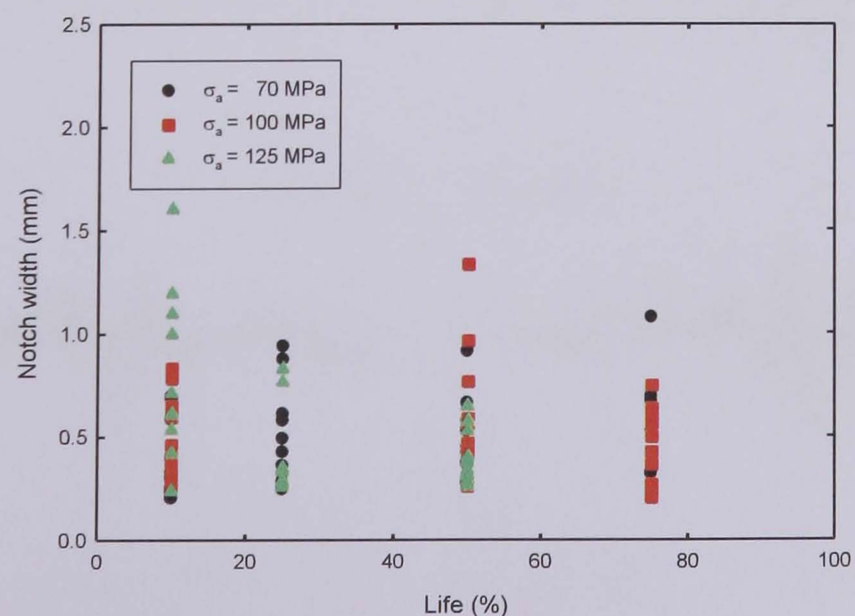
σ_n = 10 MPa:



σ_n = 60 MPa:



σ_n = 100 MPa:

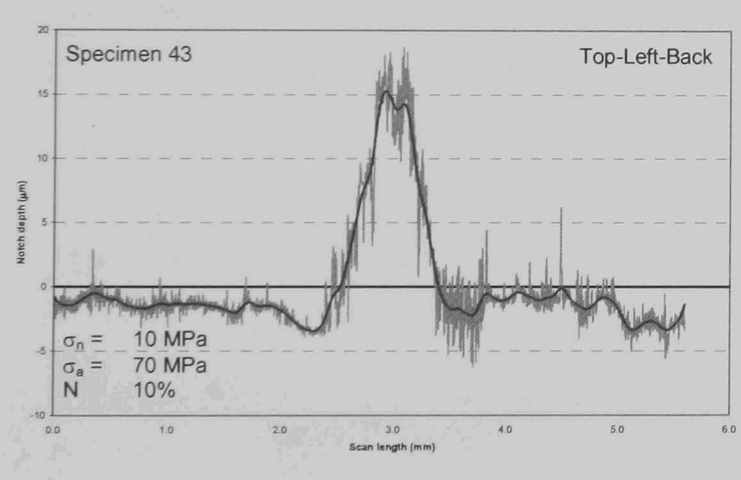


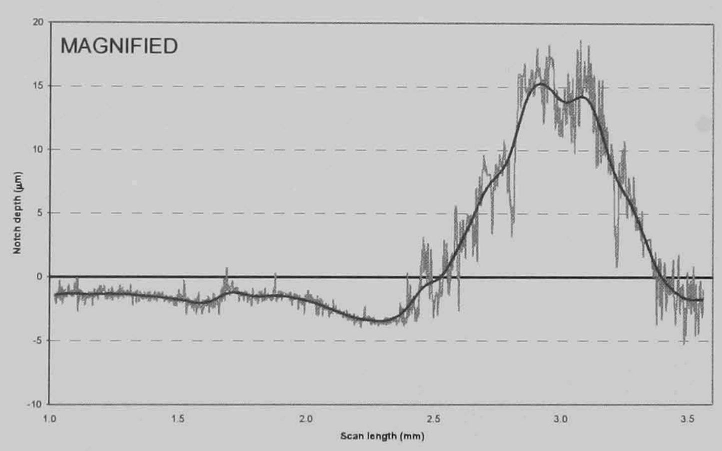
APPENDIX M

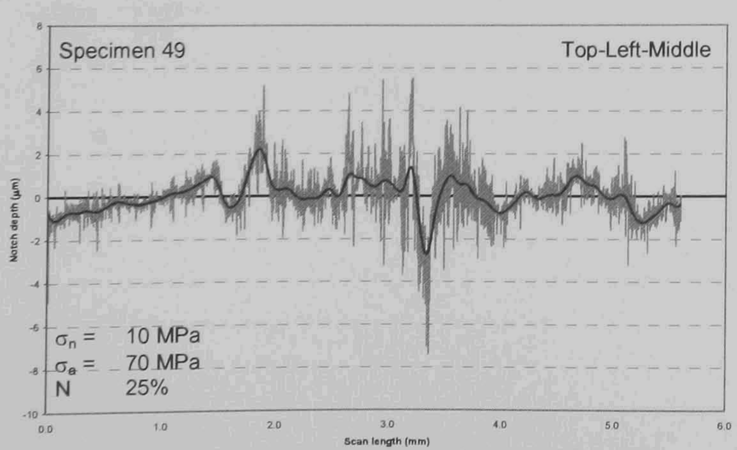
RESULTS: NOTCH DEPTH PROFILES

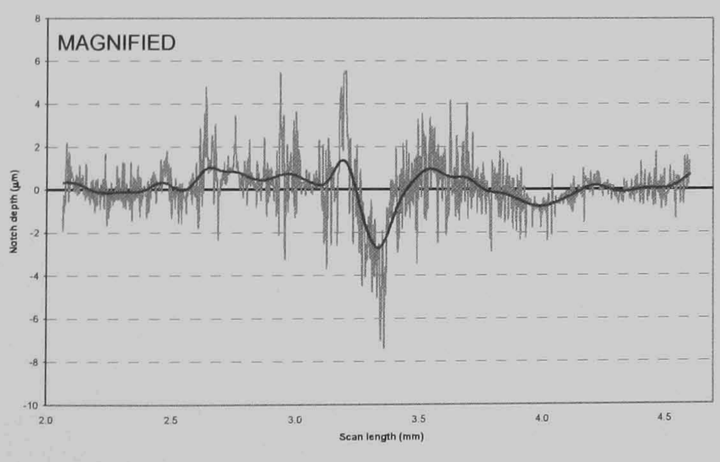
Notch depth profiles for the greatest notch depths found for each combination of normal pressure, axial stress and percentage life for both the unpeened and peened conditions, taken utilising a UBM laser profilometer, with a scan length of 5.6 mm. The original traces are shown, together with a corresponding magnified view of the areas of interest. All traces have been smoothed with a constant, σ, of 20, see Section 3.5.3.

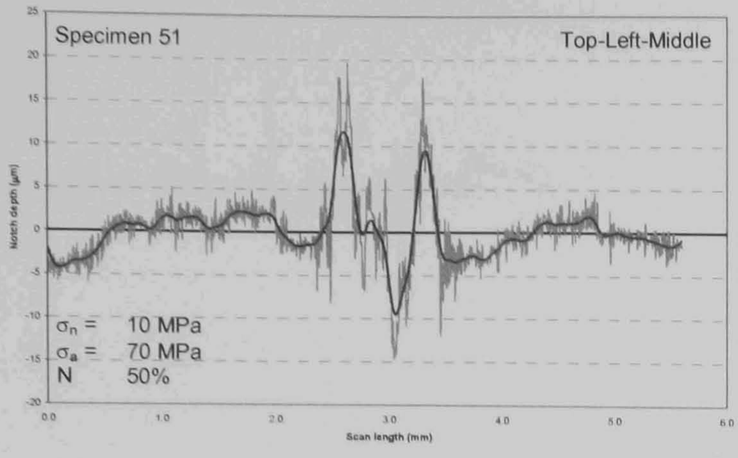
M.1 σ_a = 70 MPa unpeened

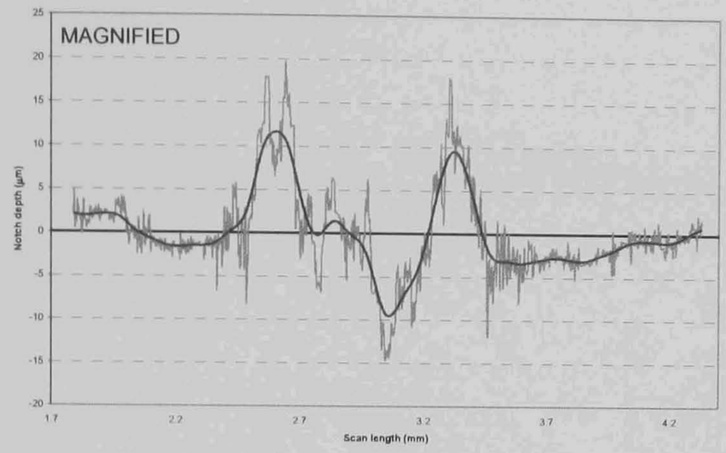


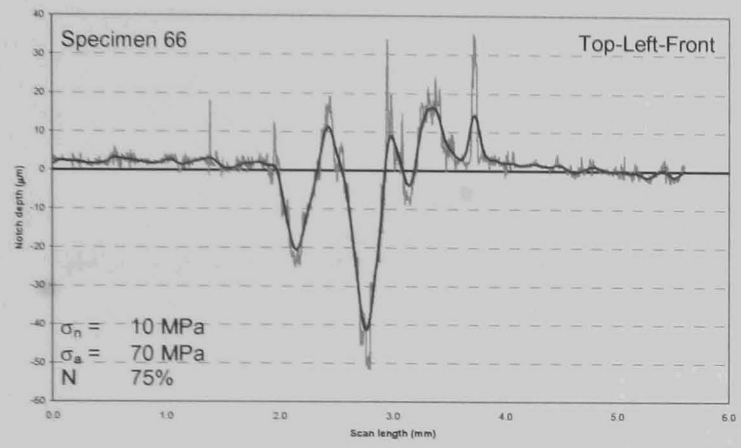


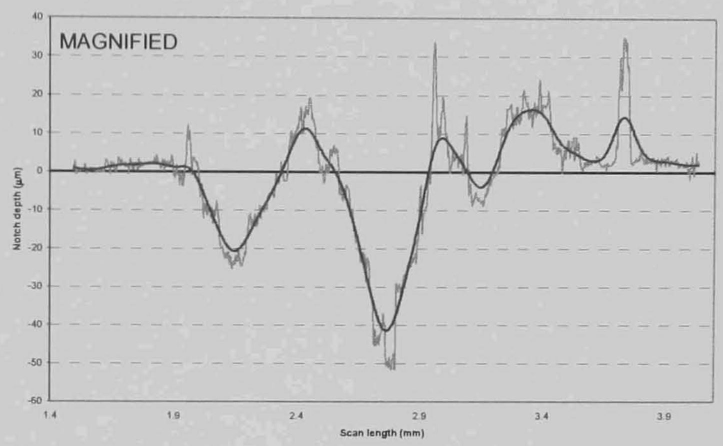


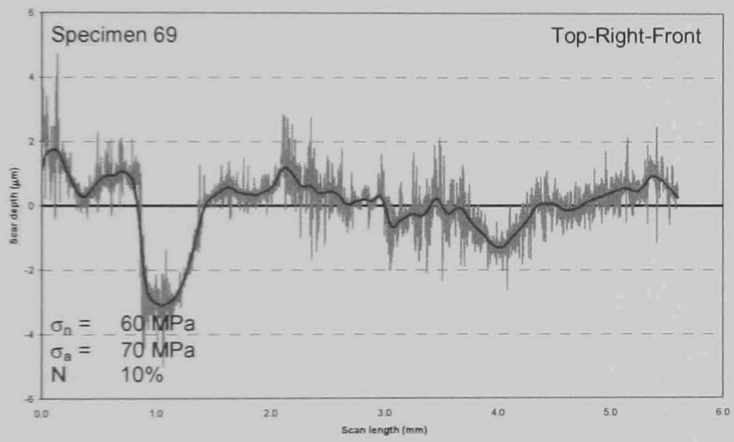


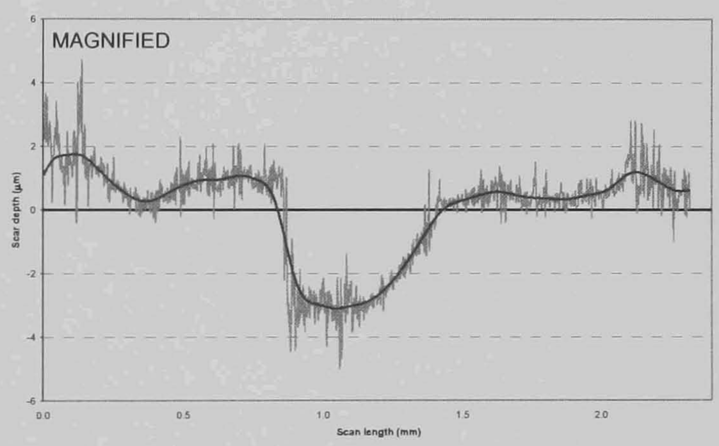

Specimen 51
Top-Left-Middle
Notch depth (µm)
Scan length (mm)
σ_n = 10 MPa
σ_a = 70 MPa
N 50%

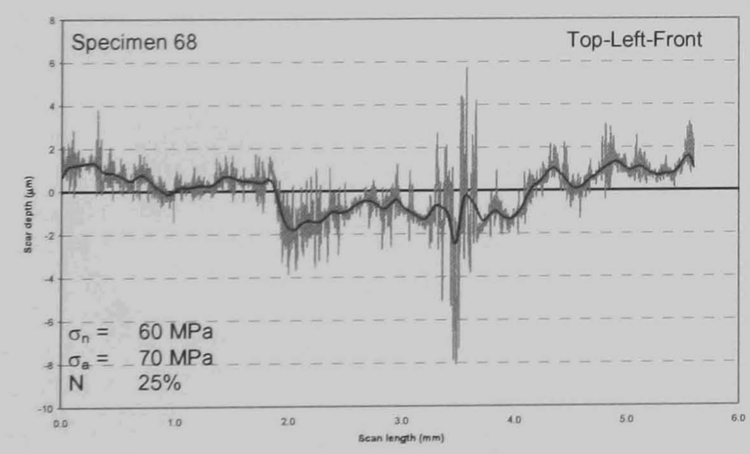

MAGNIFIED
Notch depth (µm)
Scan length (mm)

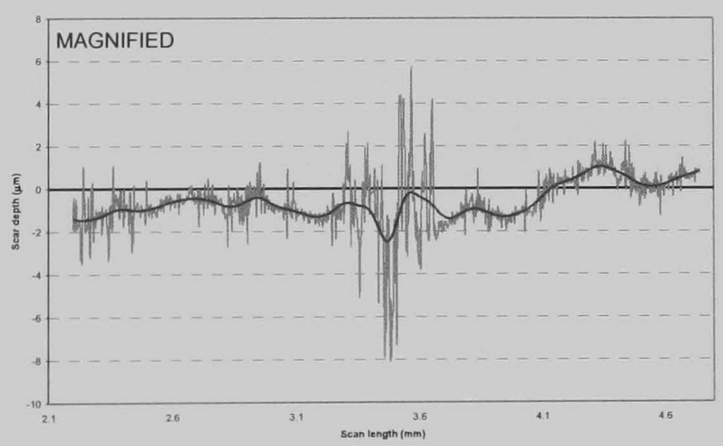

Specimen 66
Top-Left-Front
Notch depth (µm)
Scan length (mm)
σ_n = 10 MPa
σ_a = 70 MPa
N 75%

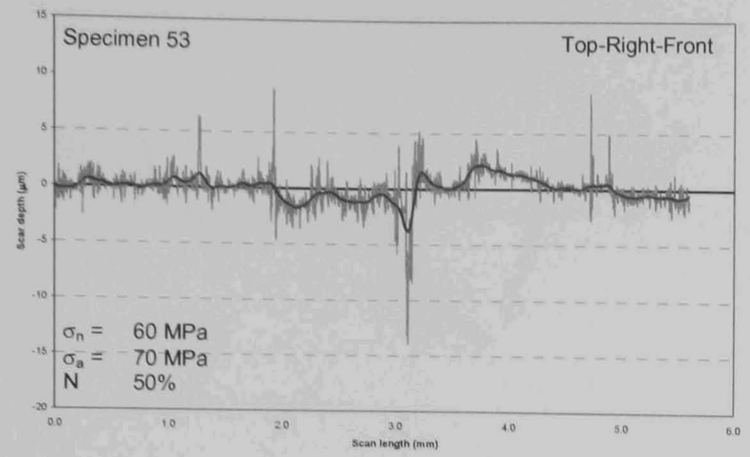

MAGNIFIED
Notch depth (µm)
Scan length (mm)

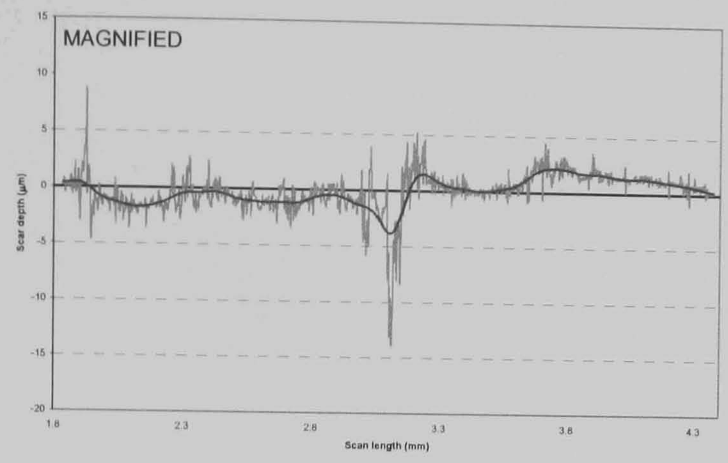

Specimen 69
Top-Right-Front
Scar depth (µm)
Scan length (mm)
σ_n = 60 MPa
σ_a = 70 MPa
N 10%

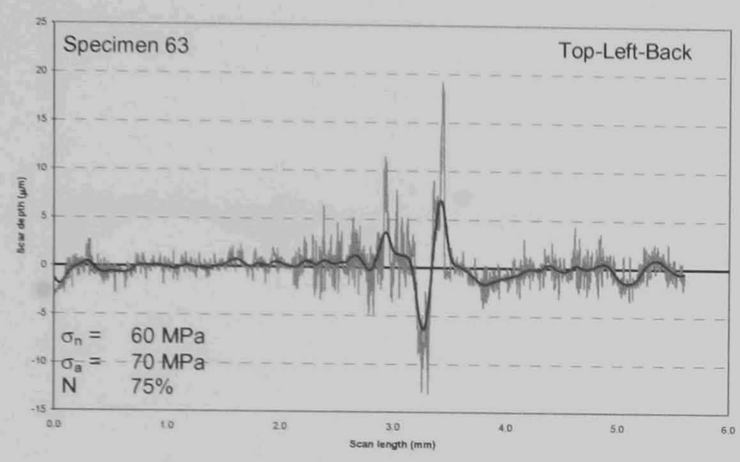

MAGNIFIED
Scar depth (µm)
Scan length (mm)

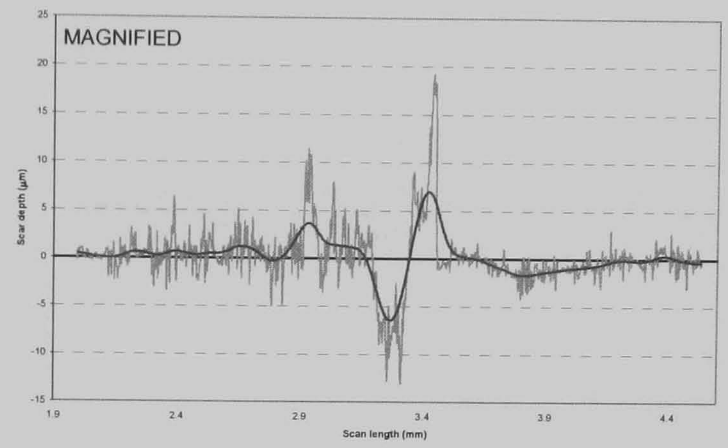

Specimen 68
Top-Left-Front
Scar depth (µm)
Scan length (mm)
σ_n = 60 MPa
σ_a = 70 MPa
N 25%

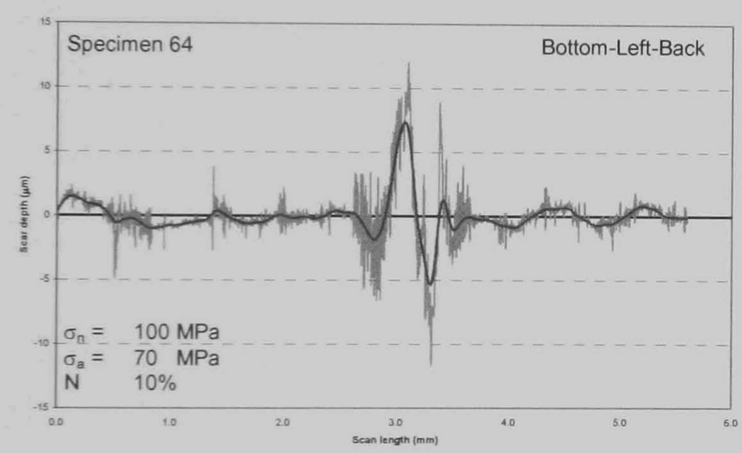

MAGNIFIED
Scar depth (µm)
Scan length (mm)

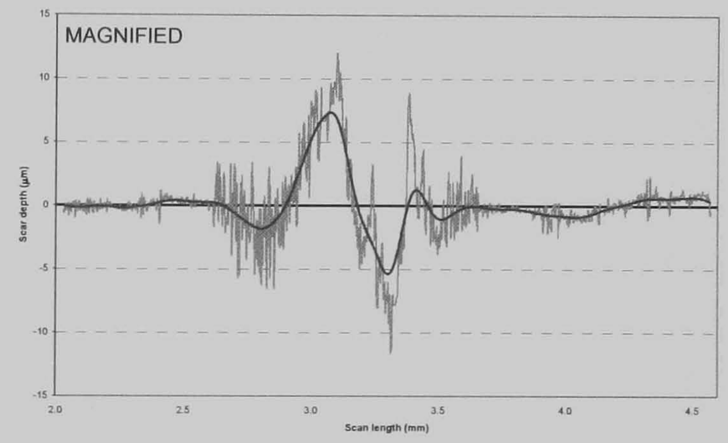

Specimen 53
Top-Right-Front
σn = 60 MPa
σa = 70 MPa
N 50%
Scar depth (µm)
Scan length (mm)

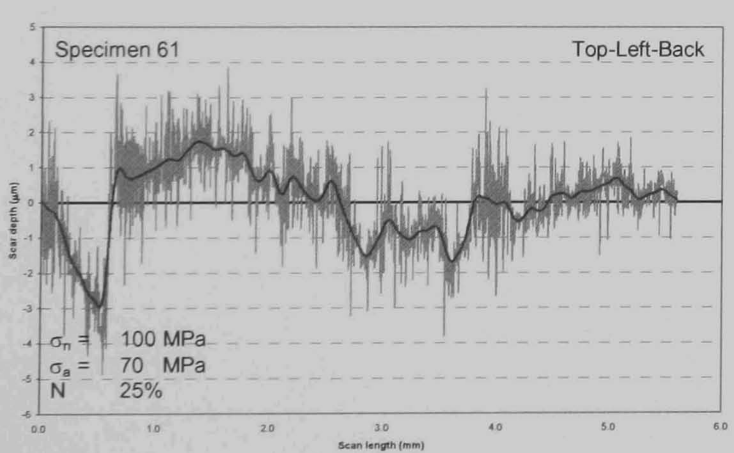

MAGNIFIED
Scar depth (µm)
Scan length (mm)

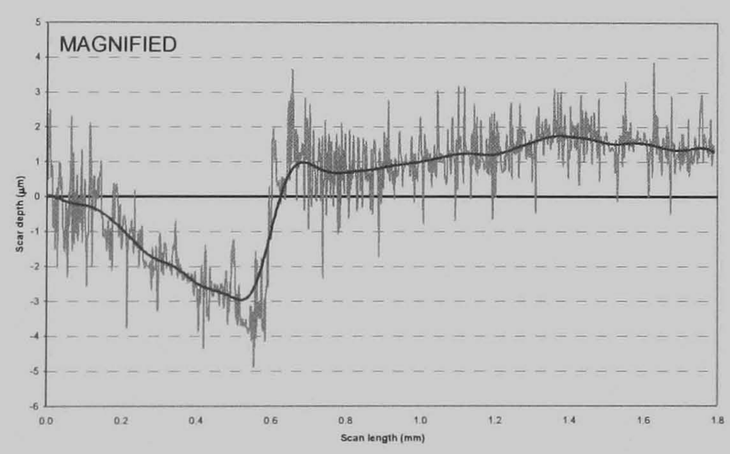

Specimen 63
Top-Left-Back
σn = 60 MPa
σa = 70 MPa
N 75%
Scar depth (µm)
Scan length (mm)

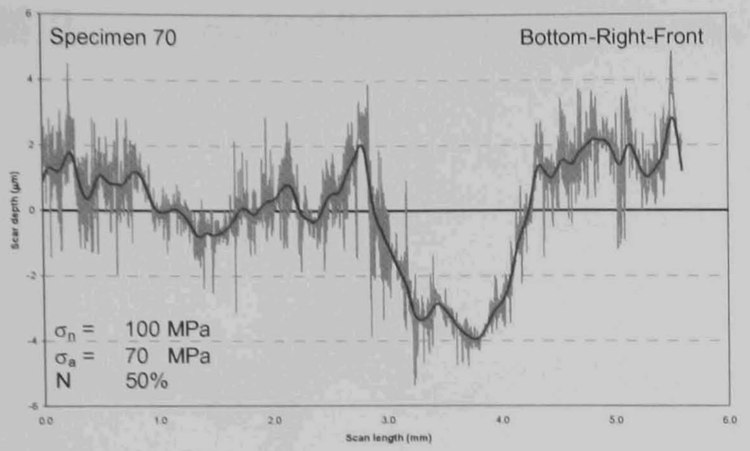

MAGNIFIED
Scar depth (µm)
Scan length (mm)

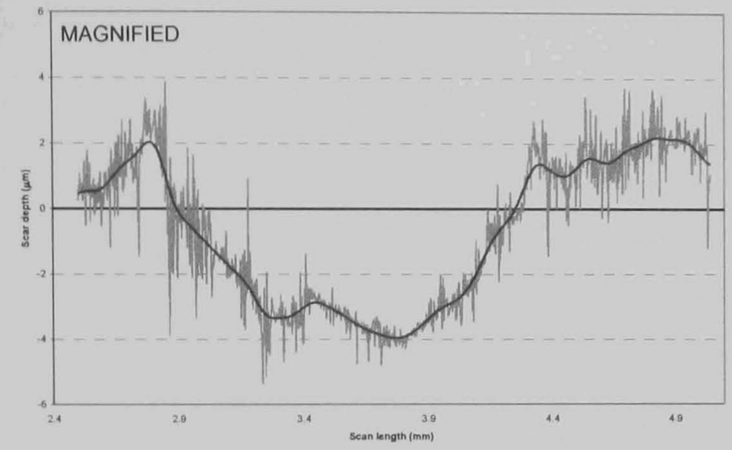

Specimen 64
Bottom-Left-Back
σn = 100 MPa
σa = 70 MPa
N 10%
Scar depth (µm)
Scan length (mm)

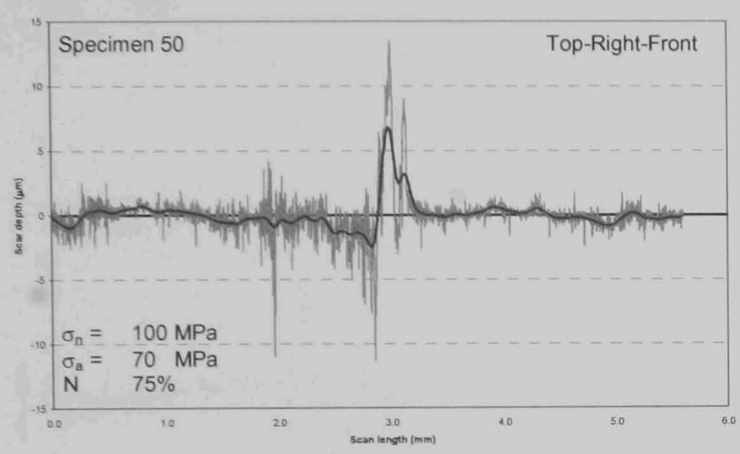

MAGNIFIED
Scar depth (µm)
Scan length (mm)

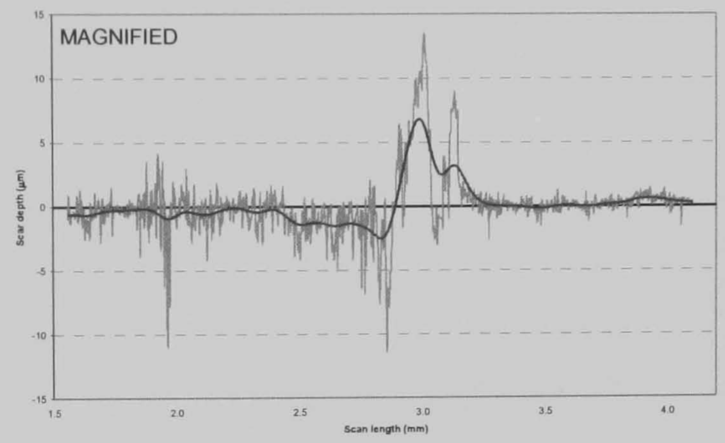

Specimen 61
Top-Left-Back
σn = 100 MPa
σa = 70 MPa
N 25%
Scar depth (µm)
Scan length (mm)


MAGNIFIED
Scar depth (µm)
Scan length (mm)

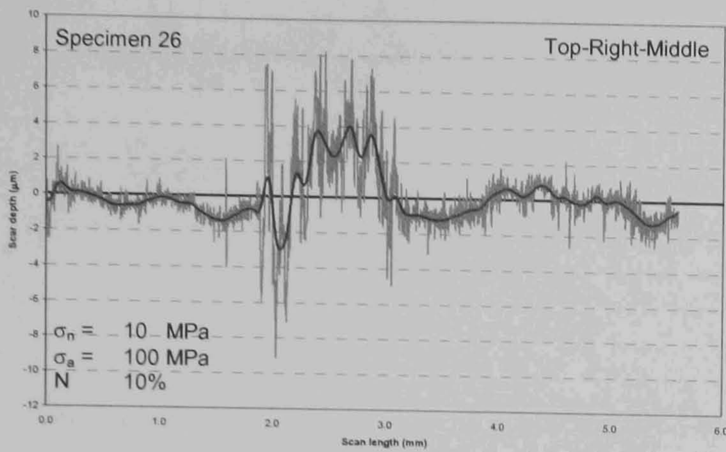

Specimen 70
Bottom-Right-Front
σn = 100 MPa
σa = 70 MPa
N 50%
Scar depth (μm)
Scan length (mm)

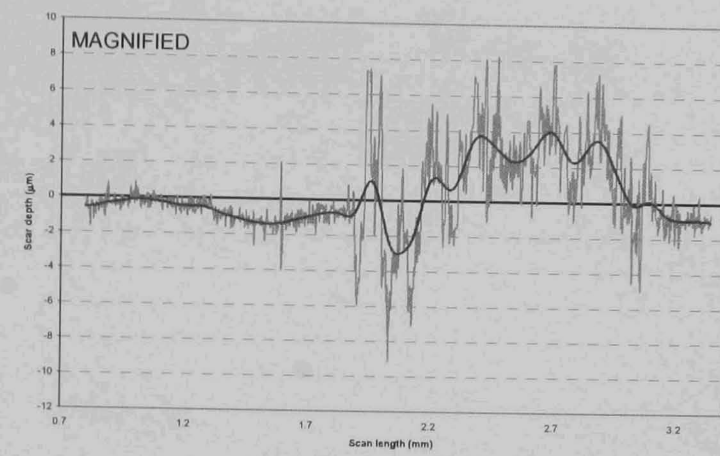

MAGNIFIED
Scar depth (μm)
Scan length (mm)

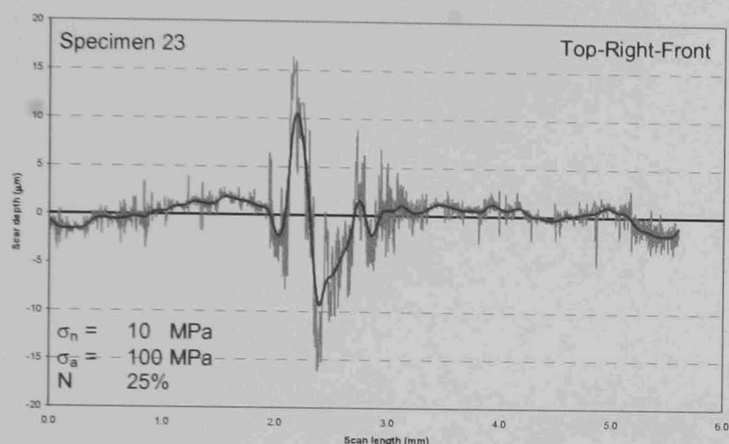

Specimen 50
Top-Right-Front
σn = 100 MPa
σa = 70 MPa
N 75%
Scar depth (μm)
Scan length (mm)

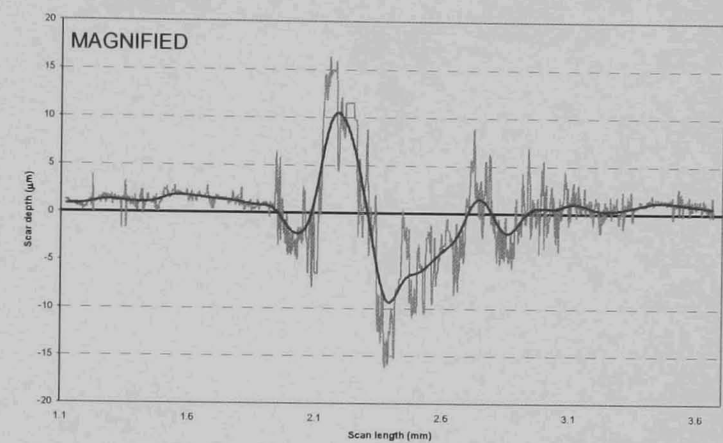

MAGNIFIED
Scar depth (μm)
Scan length (mm)

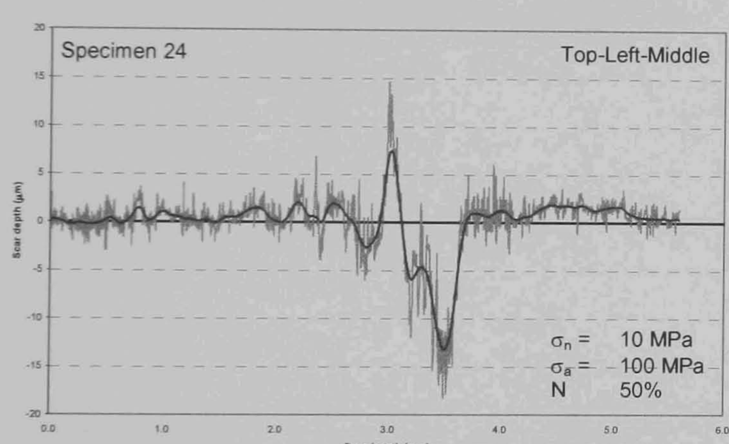
M.2 σ_a = 100 MPa unpeened

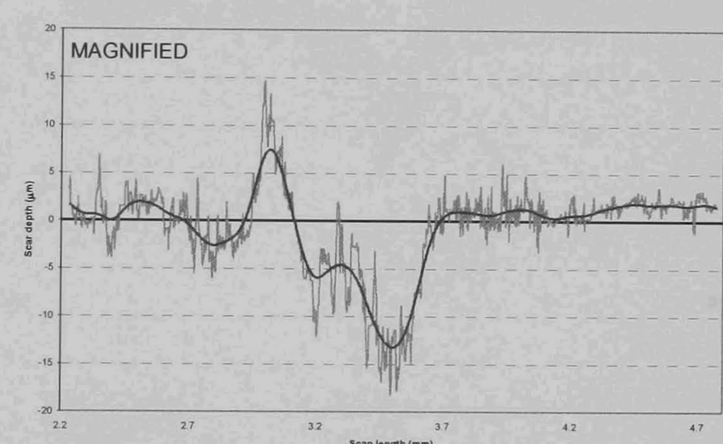


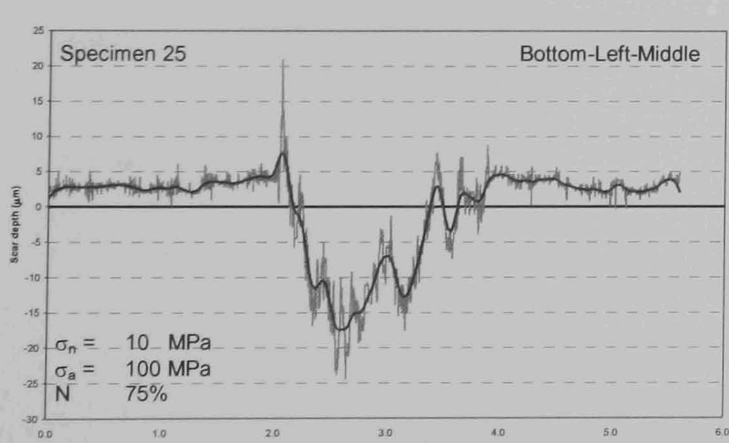


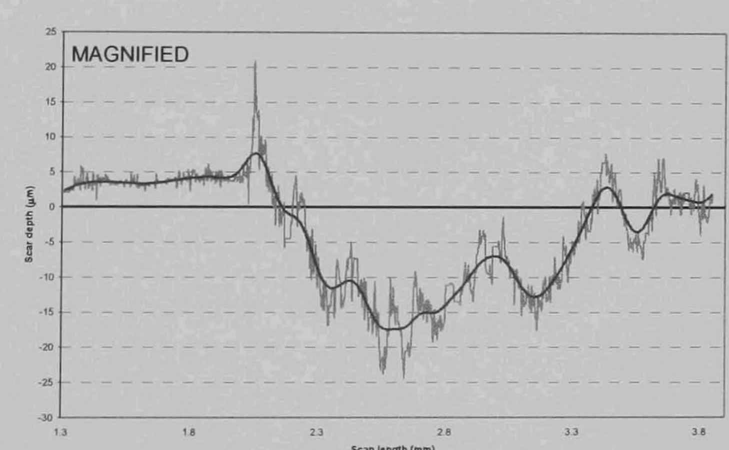


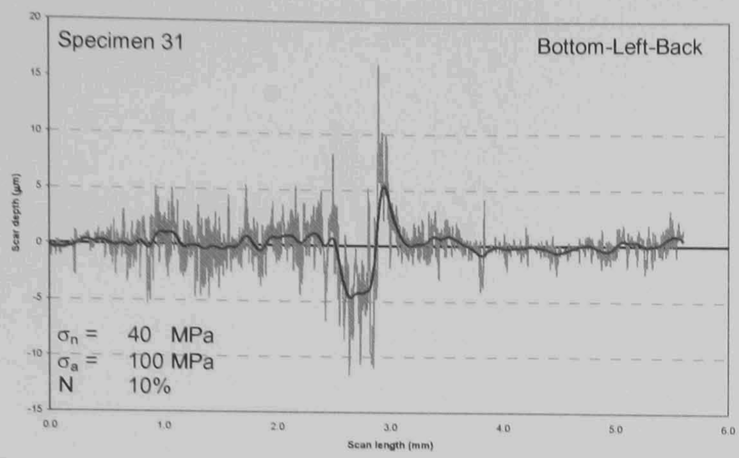


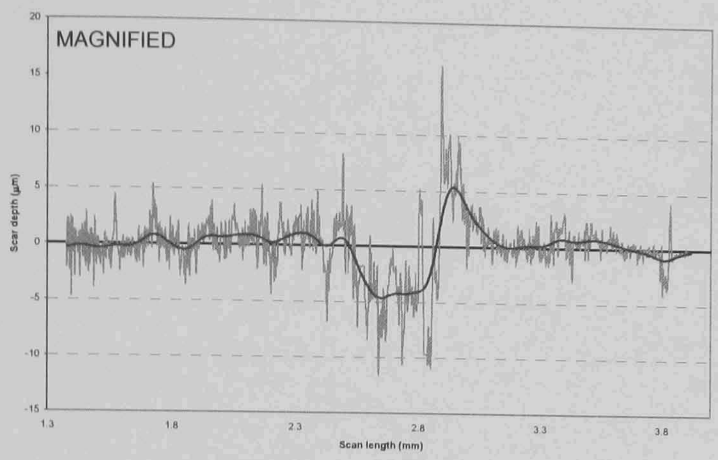


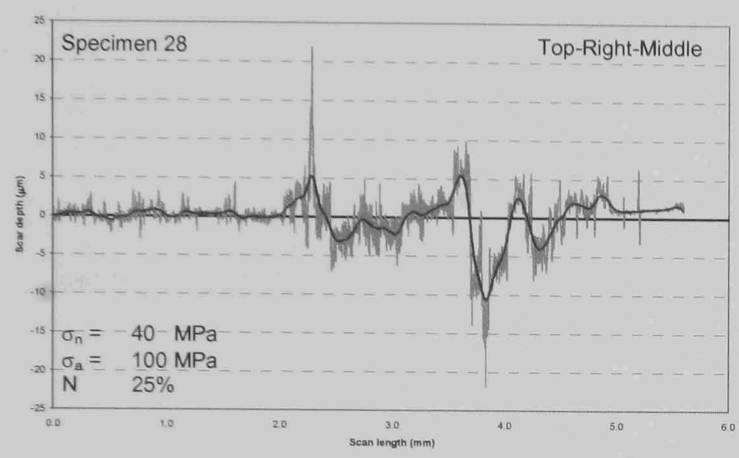


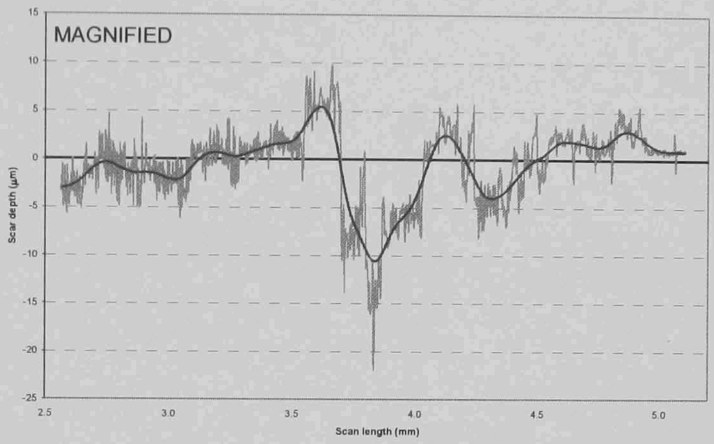


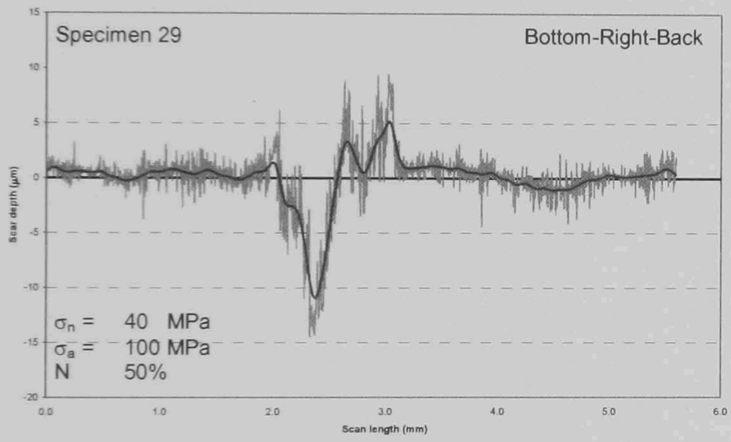


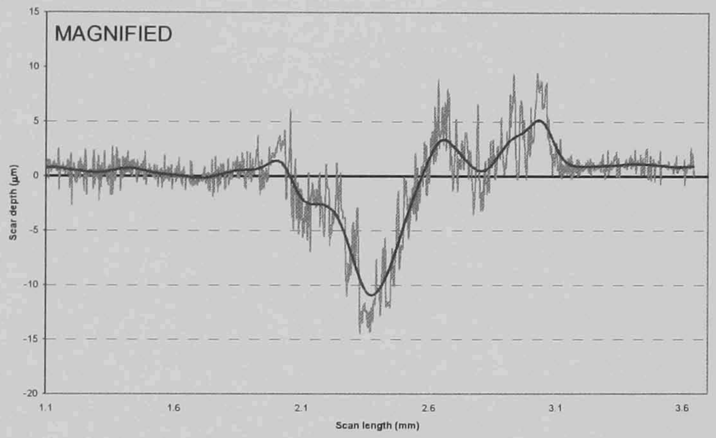

Specimen 31
Bottom-Left-Back
σ_n = 40 MPa
σ_a = 100 MPa
N 10%
Scar depth (μm)
Scan length (mm)

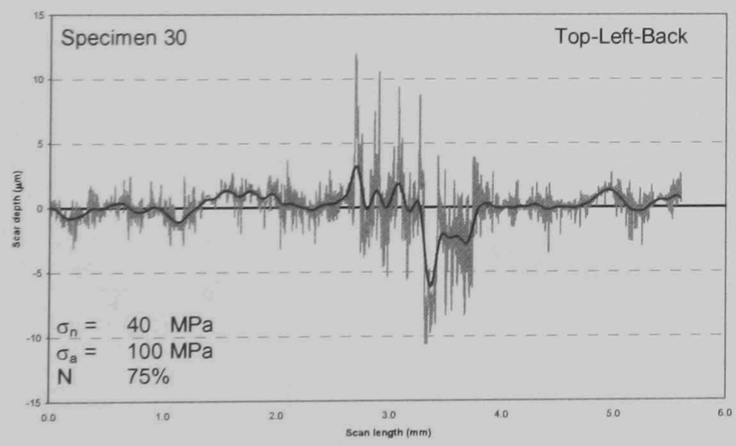

MAGNIFIED
Scar depth (μm)
Scan length (mm)

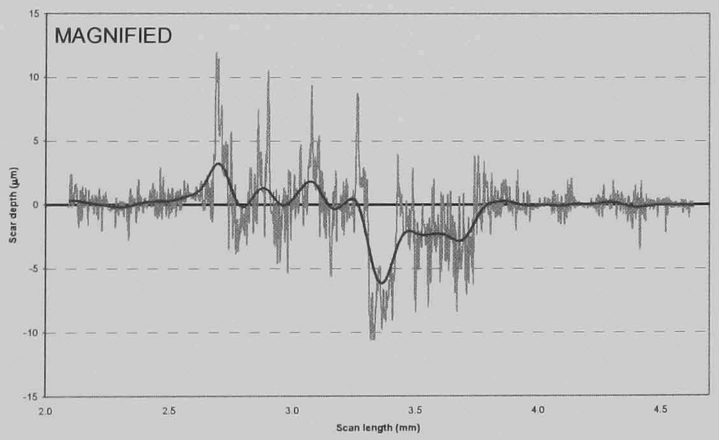

Specimen 28
Top-Right-Middle
σ_n = 40 MPa
σ_a = 100 MPa
N 25%
Scar depth (μm)
Scan length (mm)

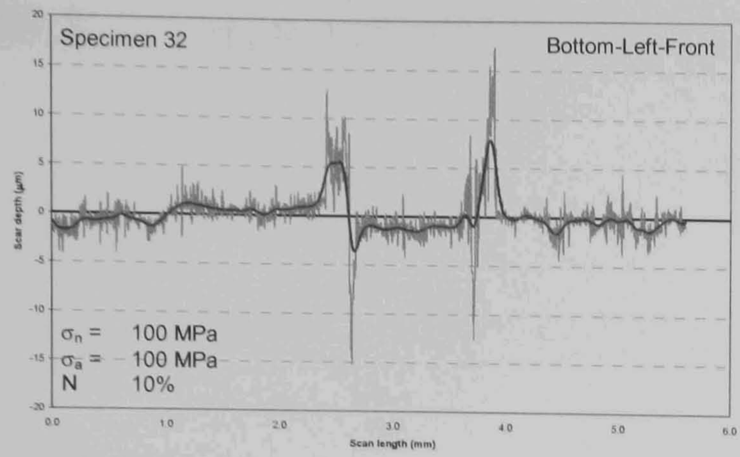

MAGNIFIED
Scar depth (μm)
Scan length (mm)

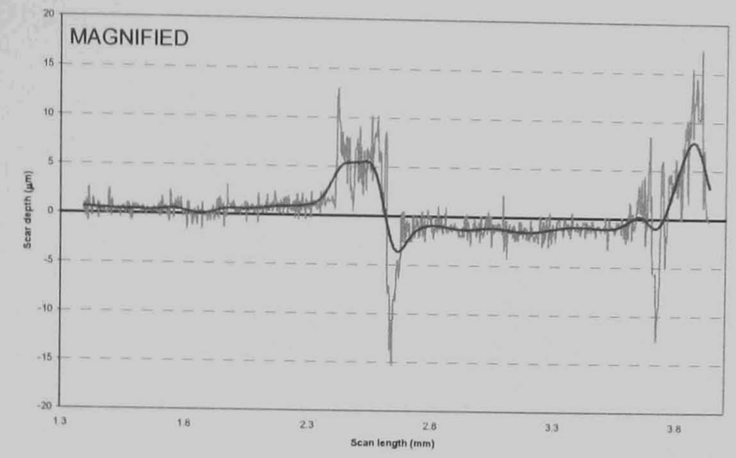

Specimen 29
Bottom-Right-Back
σ_n = 40 MPa
σ_a = 100 MPa
N 50%
Scar depth (μm)
Scan length (mm)

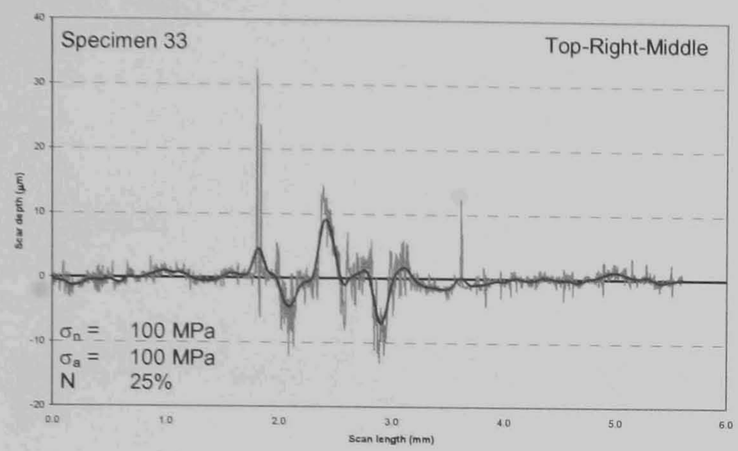

MAGNIFIED
Scar depth (μm)
Scan length (mm)

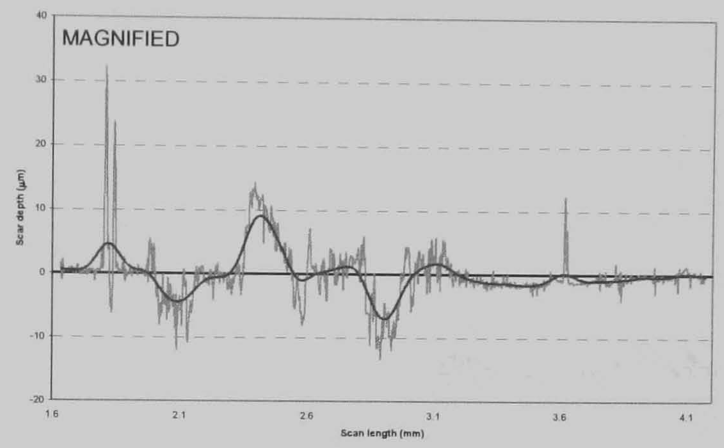

Specimen 30
Top-Left-Back
σ_n = 40 MPa
σ_a = 100 MPa
N 75%
Scar depth (μm)
Scan length (mm)

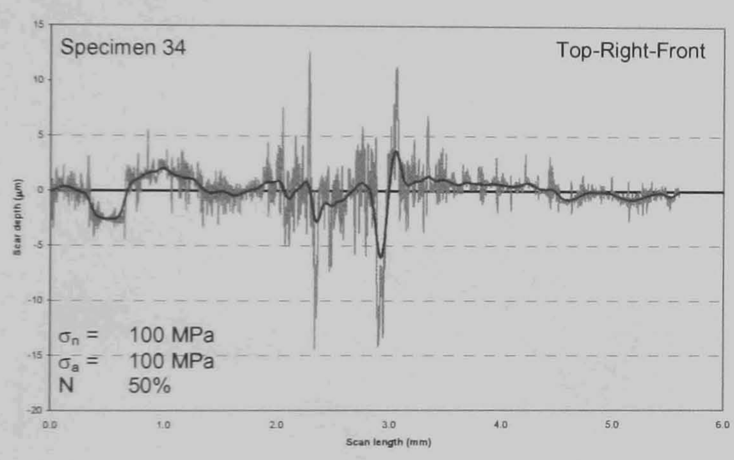

MAGNIFIED
Scar depth (μm)
Scan length (mm)

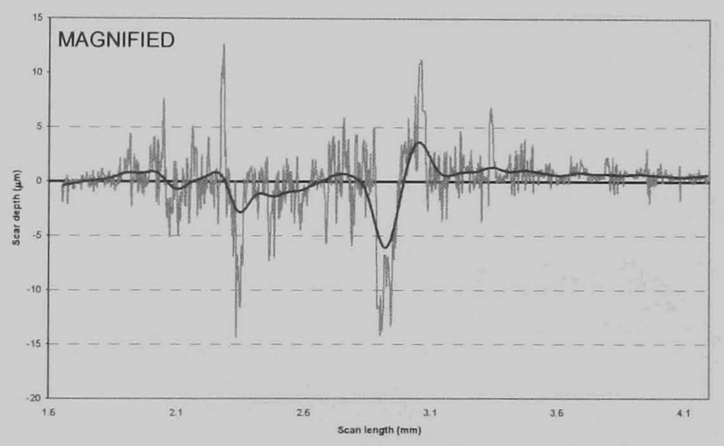

Specimen 32
Bottom-Left-Front
σn = 100 MPa
σa = 100 MPa
N 10%
Scar depth (μm)
Scan length (mm)

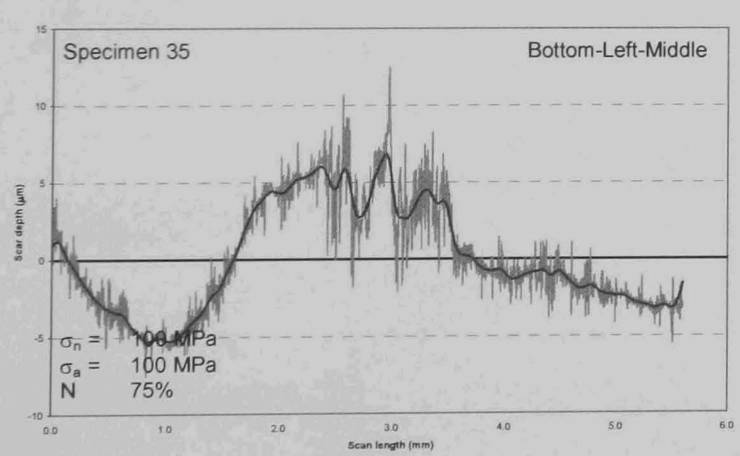

MAGNIFIED
Scar depth (μm)
Scan length (mm)

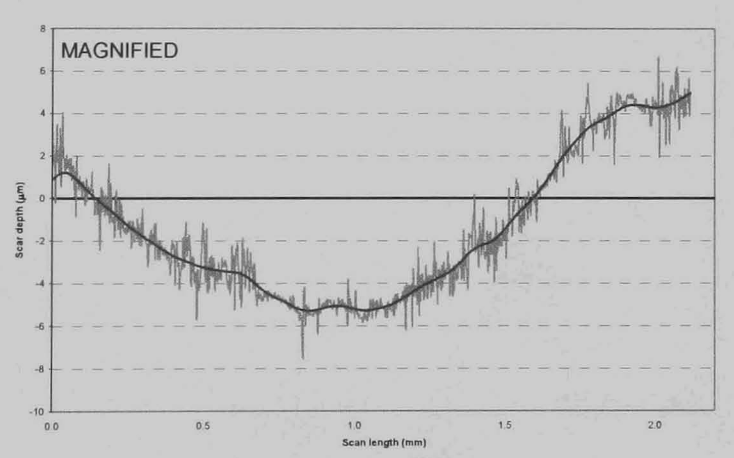

Specimen 33
Top-Right-Middle
σn = 100 MPa
σa = 100 MPa
N 25%
Scar depth (μm)
Scan length (mm)


MAGNIFIED
Scar depth (μm)
Scan length (mm)

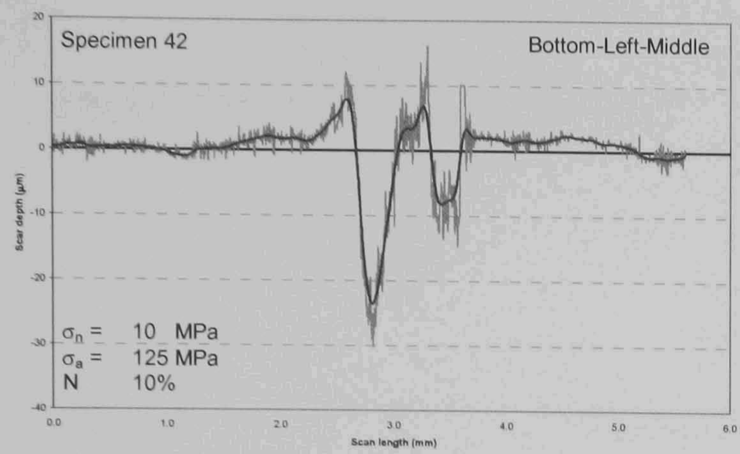

Specimen 34
Top-Right-Front
σn = 100 MPa
σa = 100 MPa
N 50%
Scar depth (μm)
Scan length (mm)

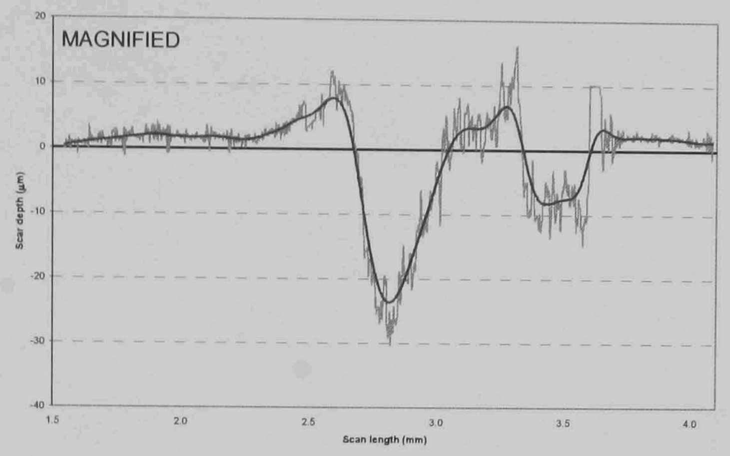

MAGNIFIED
Scar depth (μm)
Scan length (mm)

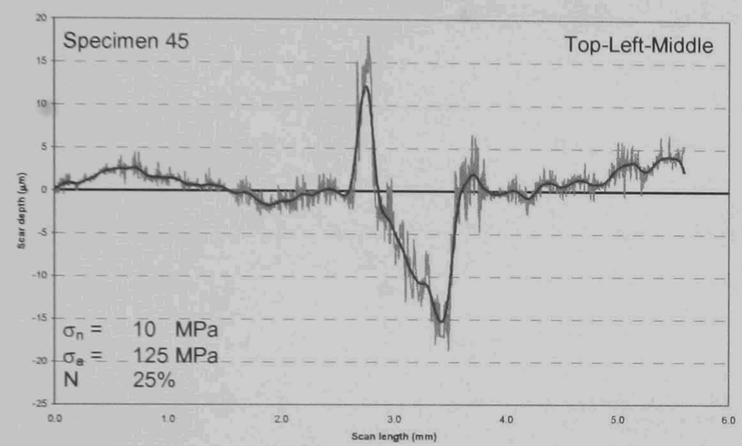

Specimen 35
Bottom-Left-Middle
σn = 100 MPa
σa = 100 MPa
N 75%
Scar depth (μm)
Scan length (mm)

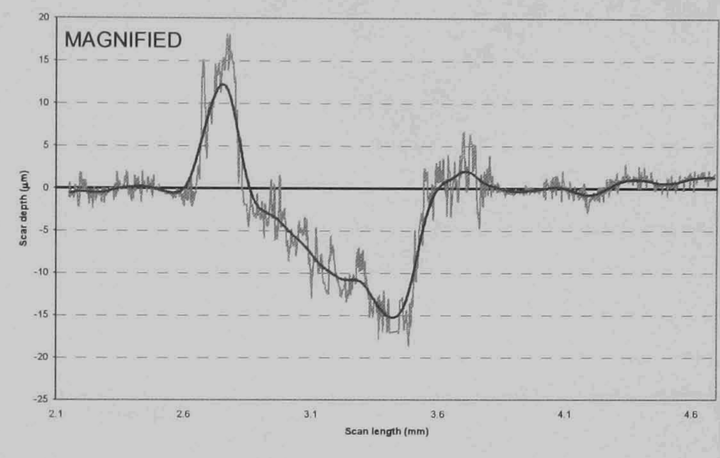

MAGNIFIED
Scar depth (μm)
Scan length (mm)

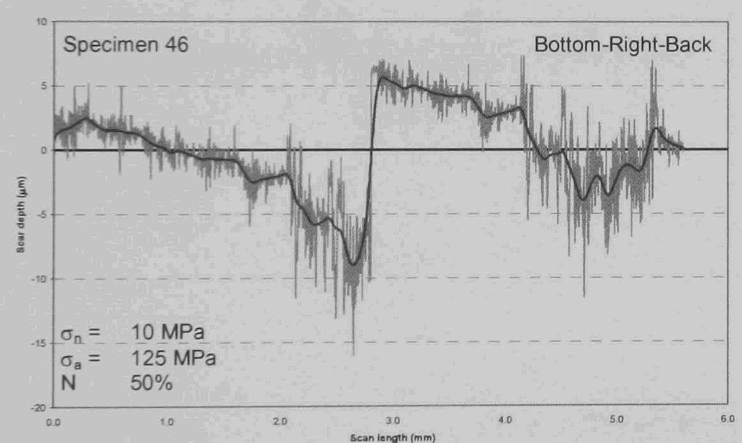
M.3 σ_a = 125 MPa unpeened

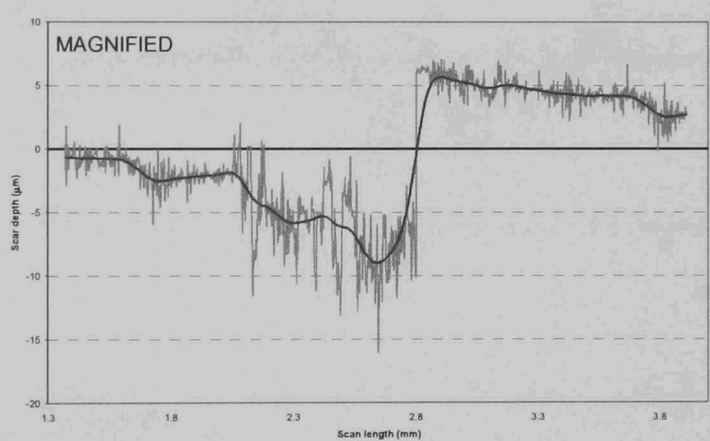


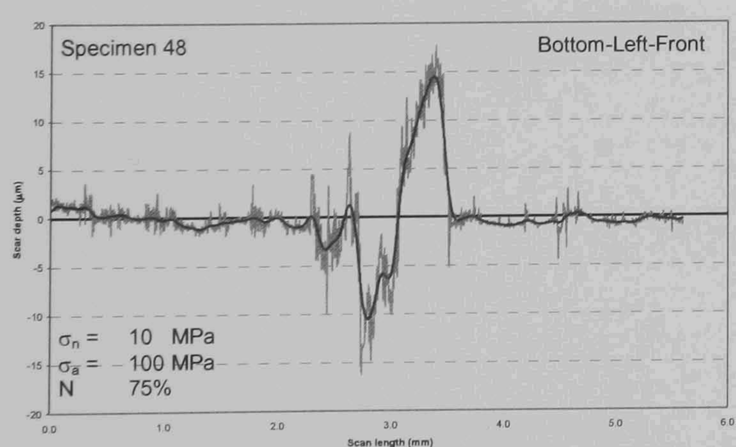


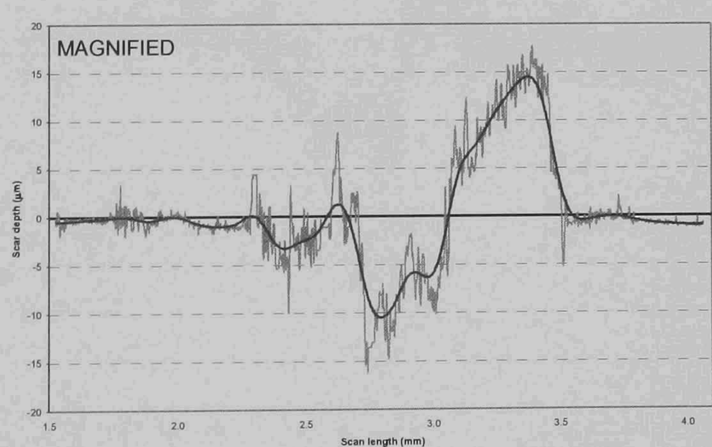


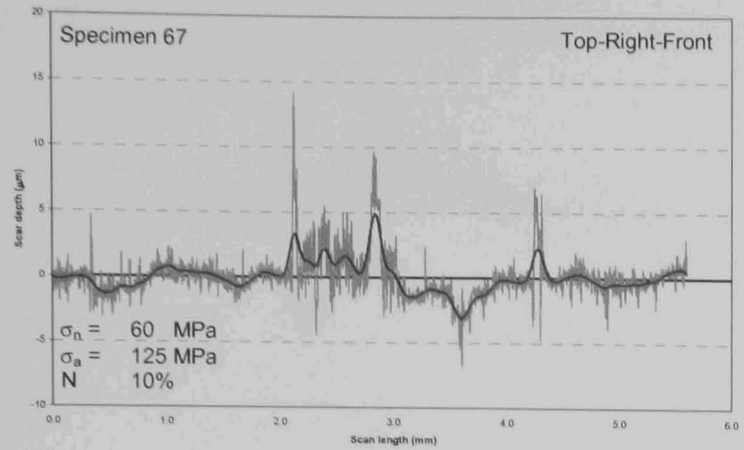


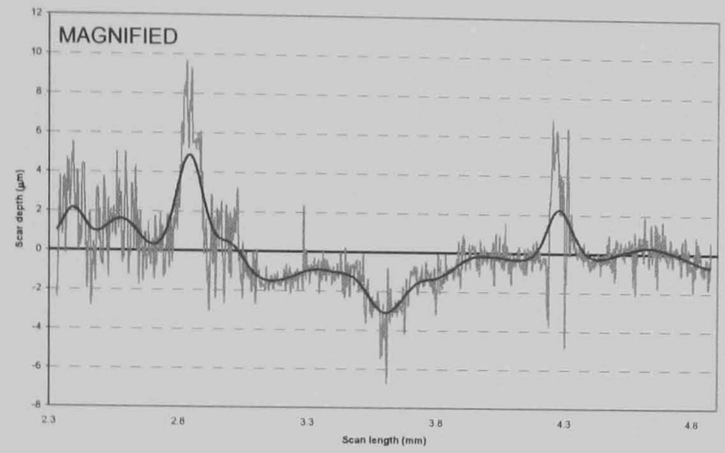


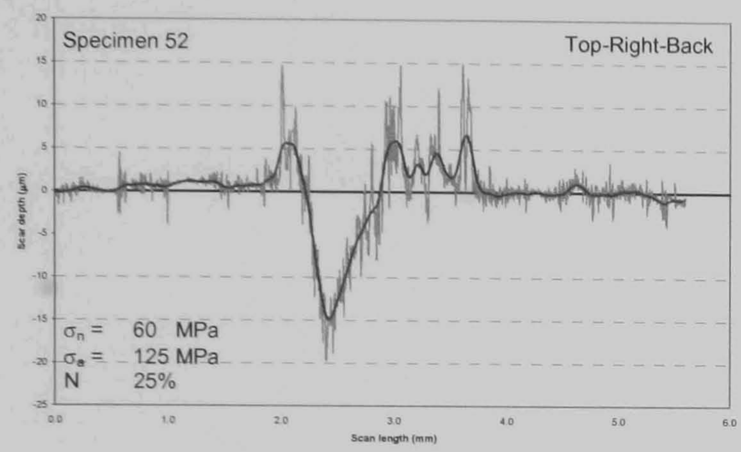


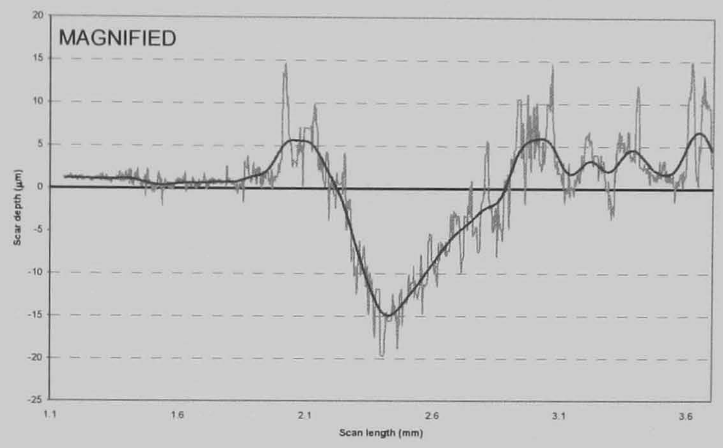


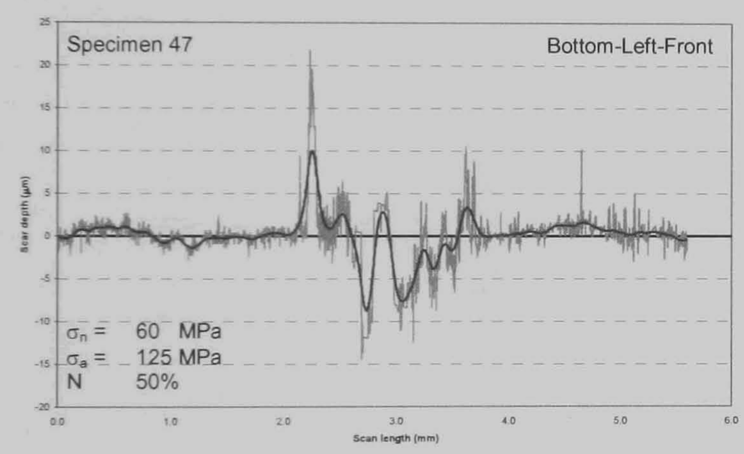


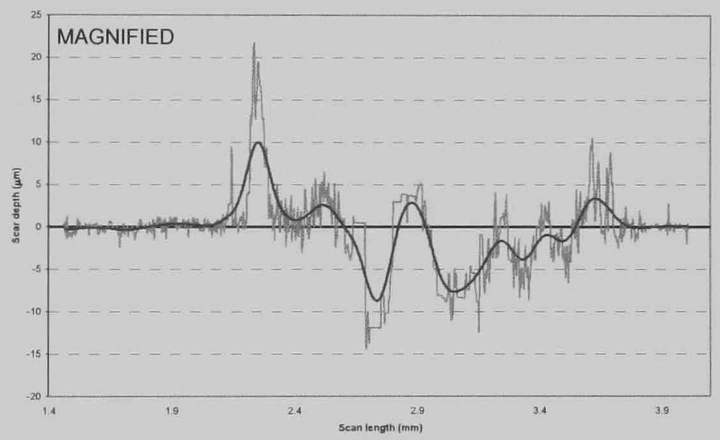

Specimen 67
Top-Right-Front
σn = 60 MPa
σa = 125 MPa
N 10%
Scar depth (μm)
Scan length (mm)

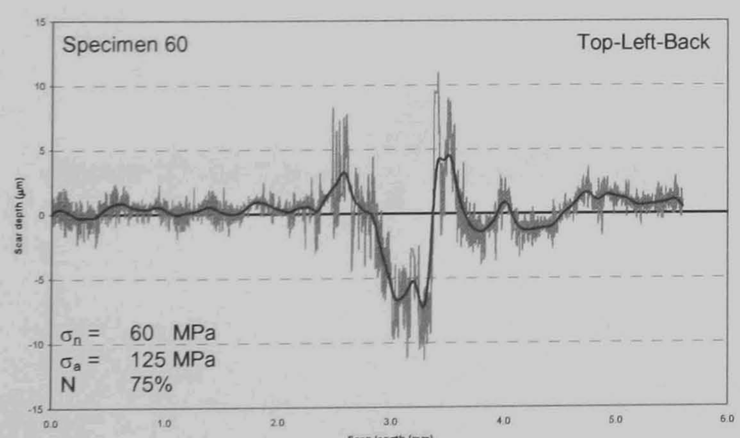

MAGNIFIED
Scar depth (μm)
Scan length (mm)

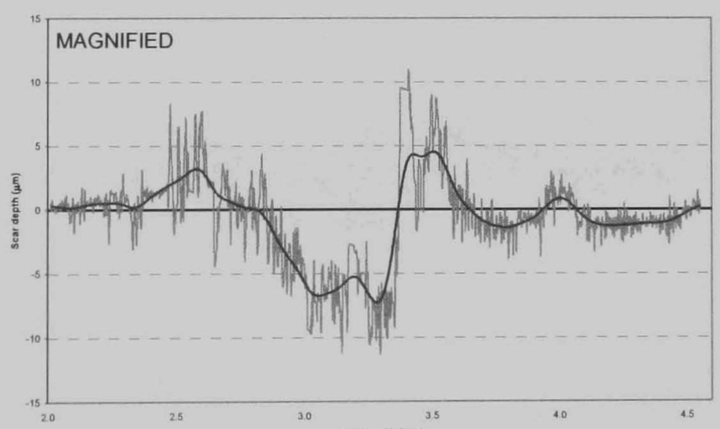

Specimen 52
Top-Right-Back
σn = 60 MPa
σa = 125 MPa
N 25%
Scar depth (μm)
Scan length (mm)

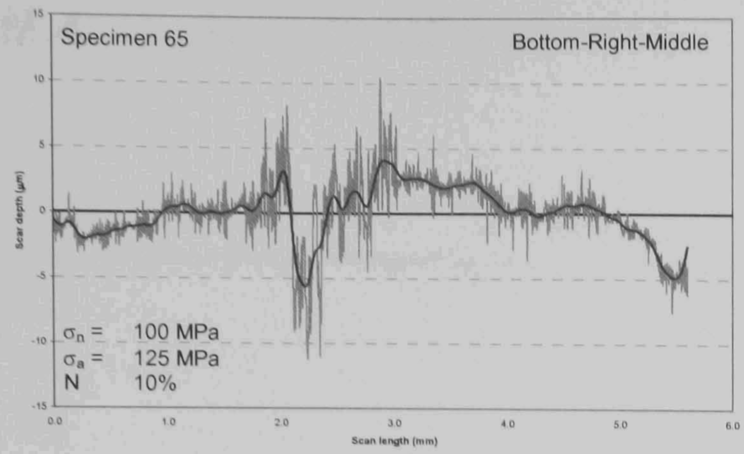

MAGNIFIED
Scar depth (μm)
Scan length (mm)

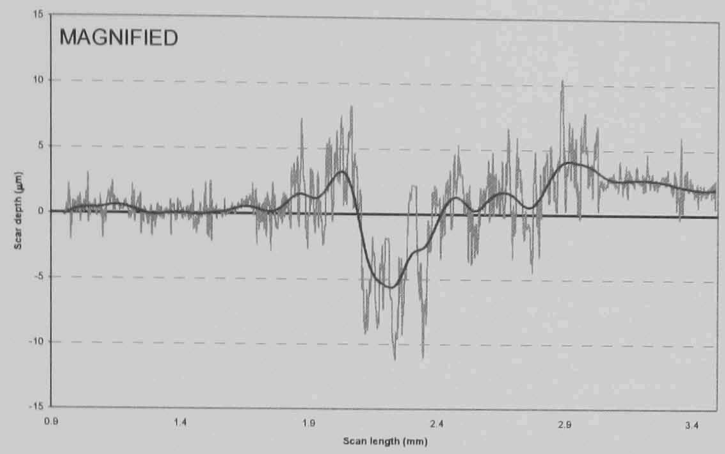

Specimen 47
Bottom-Left-Front
σn = 60 MPa
σa = 125 MPa
N 50%
Scar depth (μm)
Scan length (mm)

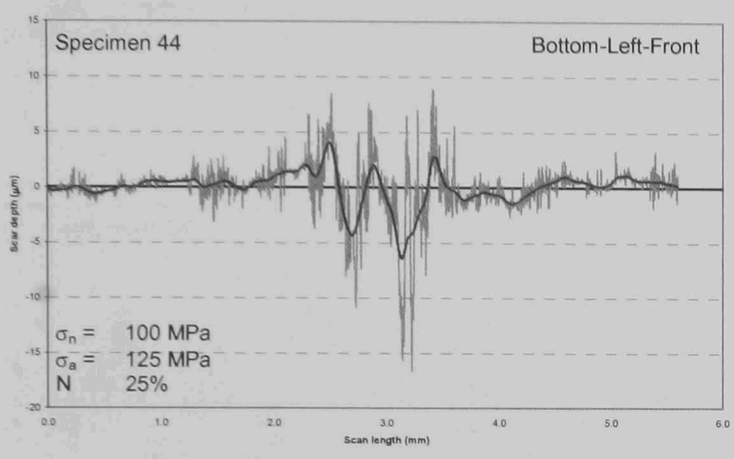

MAGNIFIED
Scar depth (μm)
Scan length (mm)

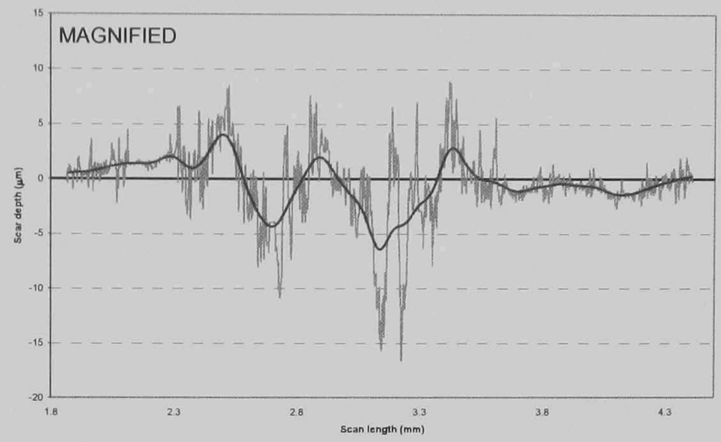

Specimen 60
Top-Left-Back
σn = 60 MPa
σa = 125 MPa
N 75%
Scar depth (μm)
Scan length (mm)

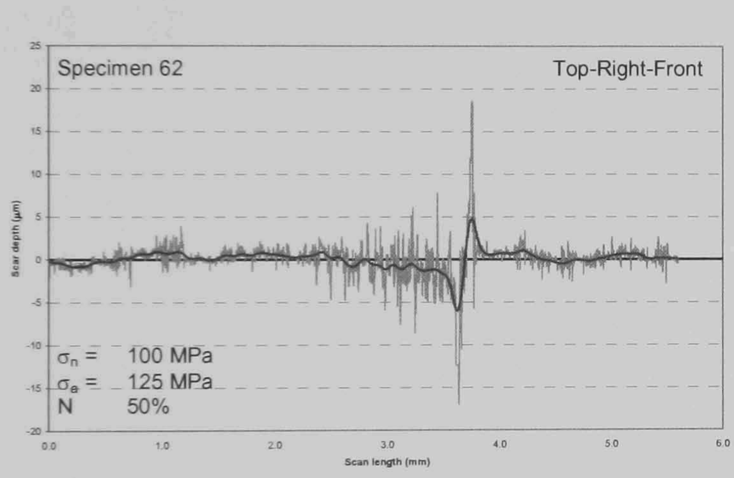

MAGNIFIED
Scar depth (μm)
Scan length (mm)

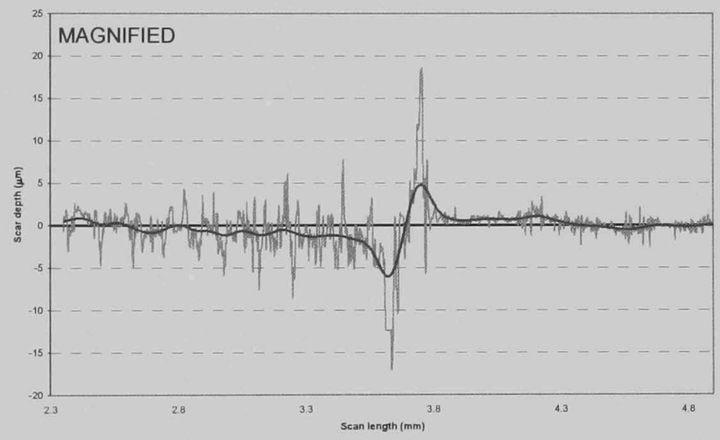

Specimen 65
Bottom-Right-Middle
σ_n = 100 MPa
σ_a = 125 MPa
N 10%
Scar depth (µm)
Scan length (mm)

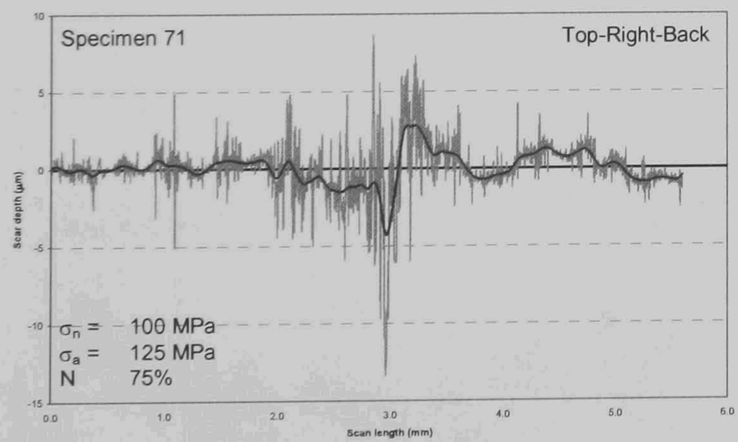

MAGNIFIED
Scar depth (µm)
Scan length (mm)

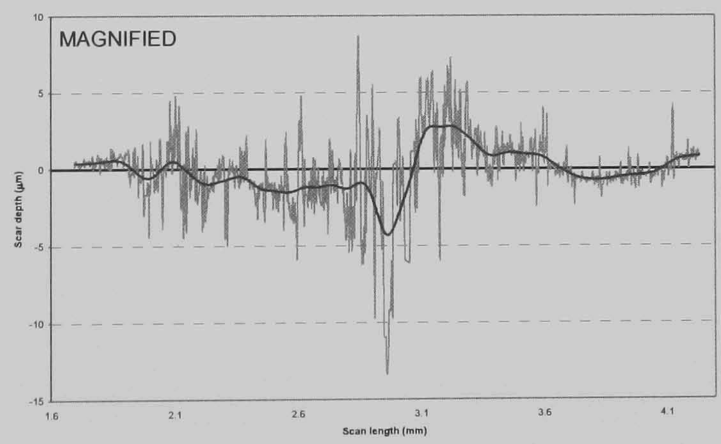

Specimen 44
Bottom-Left-Front
σ_n = 100 MPa
σ_a = 125 MPa
N 25%
Scar depth (µm)
Scan length (mm)


MAGNIFIED
Scar depth (µm)
Scan length (mm)

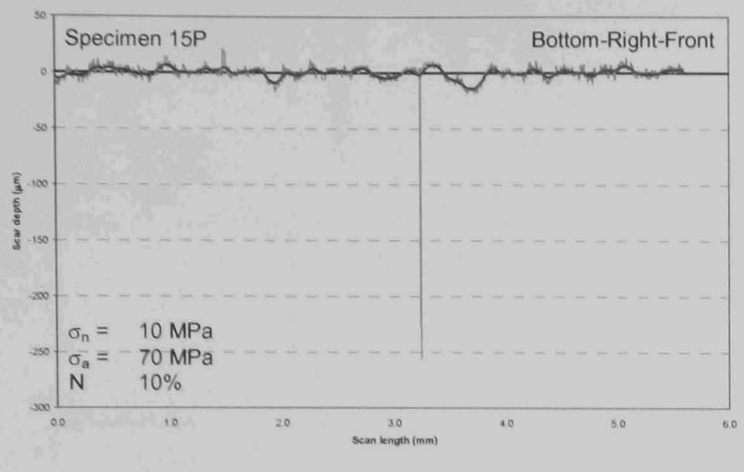

Specimen 62
Top-Right-Front
σ_n = 100 MPa
σ_a = 125 MPa
N 50%
Scar depth (µm)
Scan length (mm)

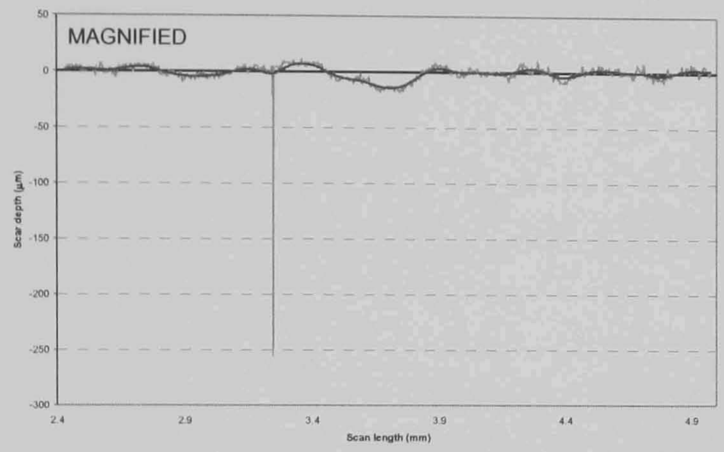

MAGNIFIED
Scar depth (µm)
Scan length (mm)

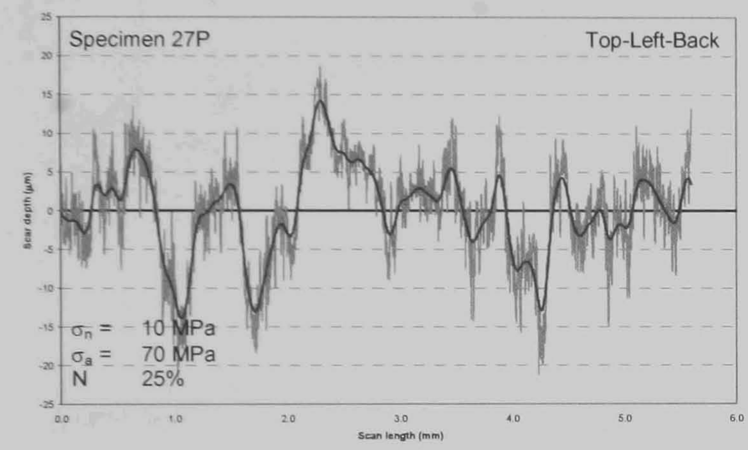

Specimen 71
Top-Right-Back
σ_n = 100 MPa
σ_a = 125 MPa
N 75%
Scar depth (µm)
Scan length (mm)

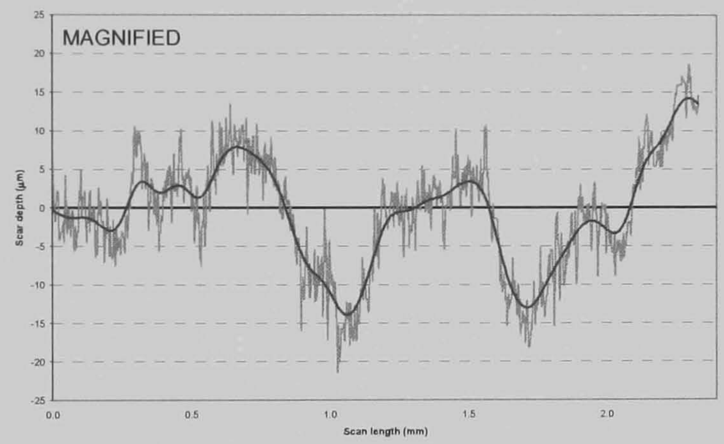

MAGNIFIED
Scar depth (µm)
Scan length (mm)

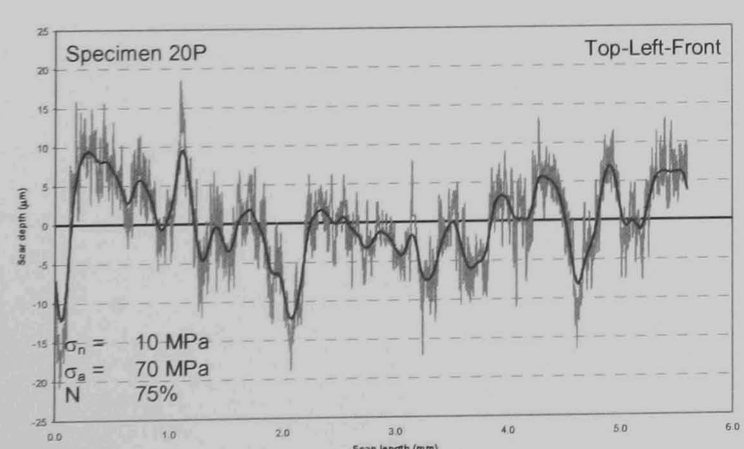
M.4 σ_a = 70 MPa peened

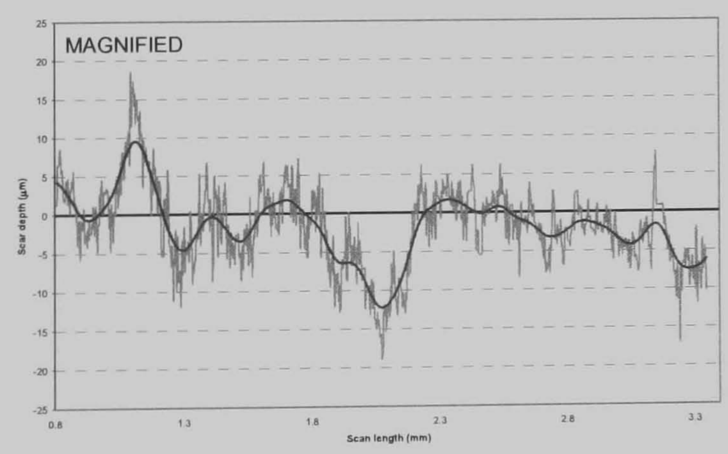


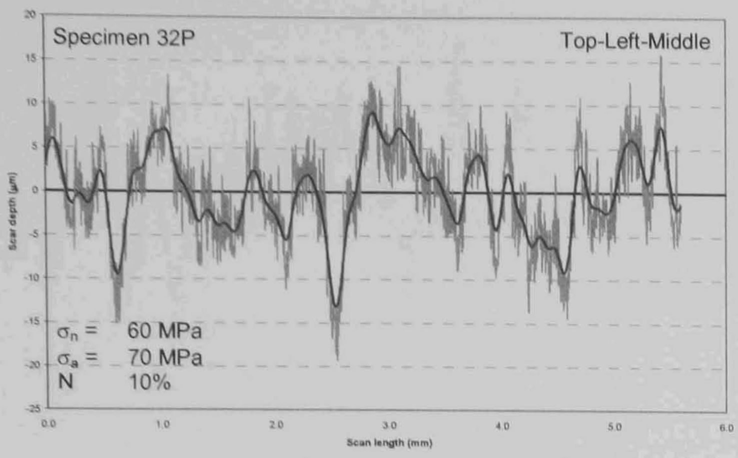


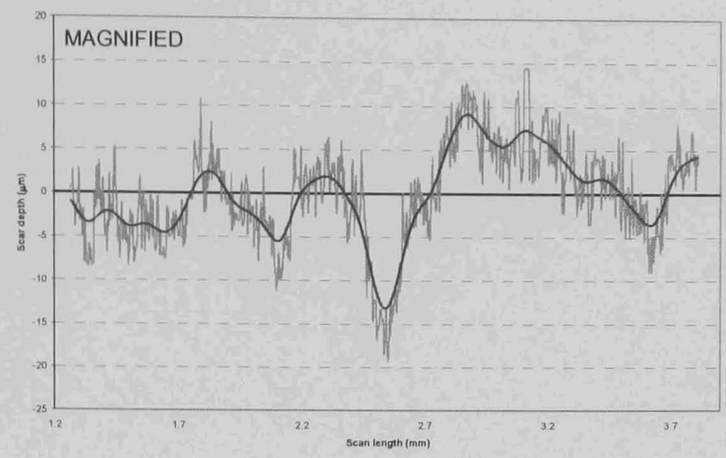


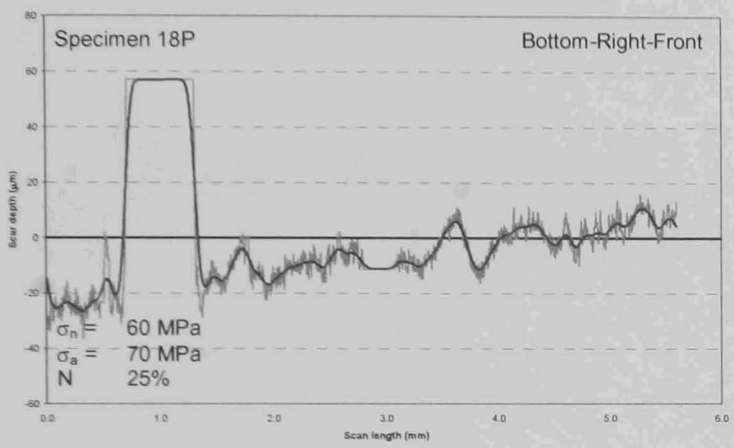


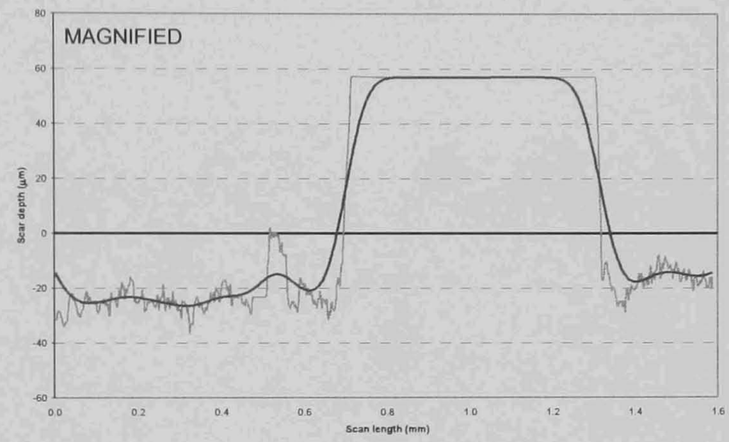


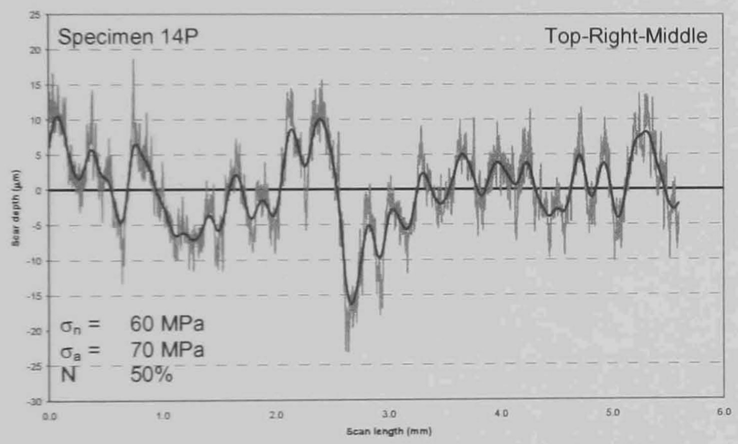


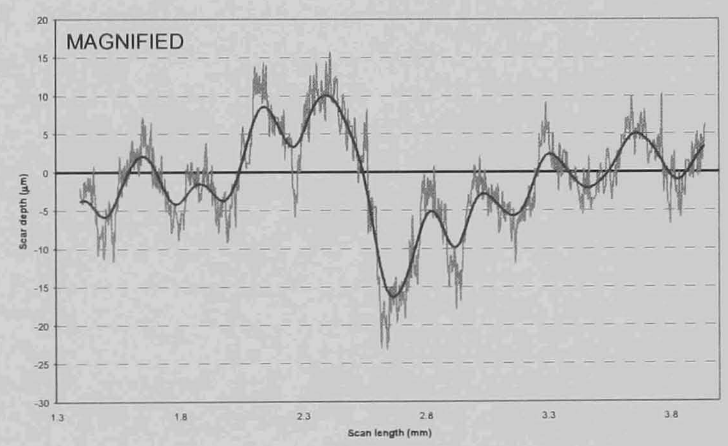

Specimen 32P
Top-Left-Middle
σ_n = 60 MPa
σ_a = 70 MPa
N 10%
Scan length (mm)
Scar depth (μm)

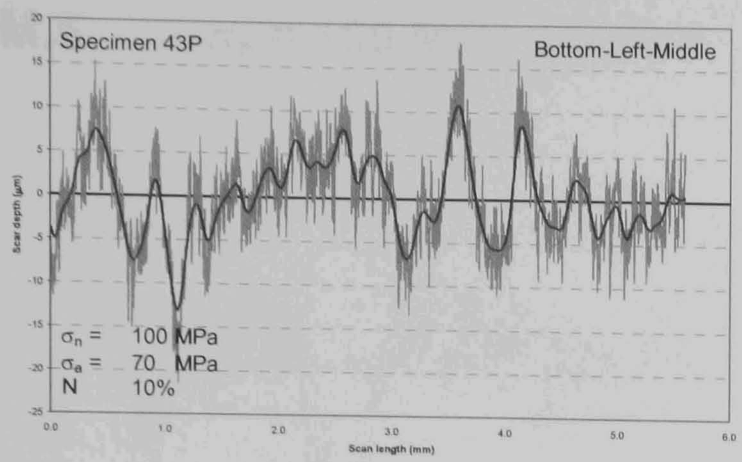

MAGNIFIED
Scan length (mm)
Scar depth (μm)

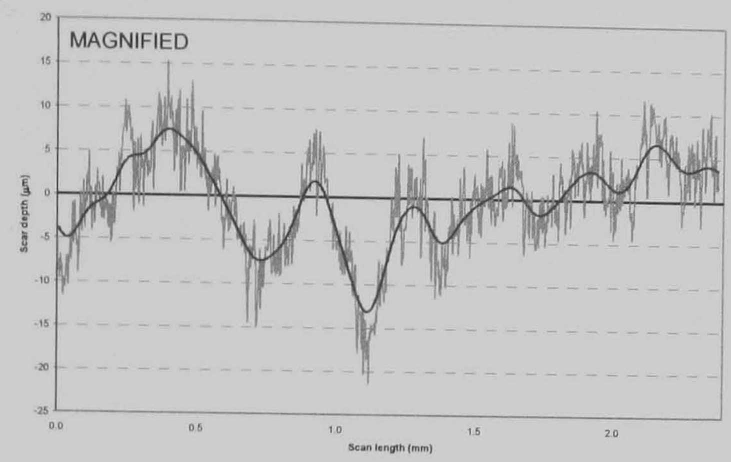

Specimen 18P
Bottom-Right-Front
σ_n = 60 MPa
σ_a = 70 MPa
N 25%
Scan length (mm)
Scar depth (μm)

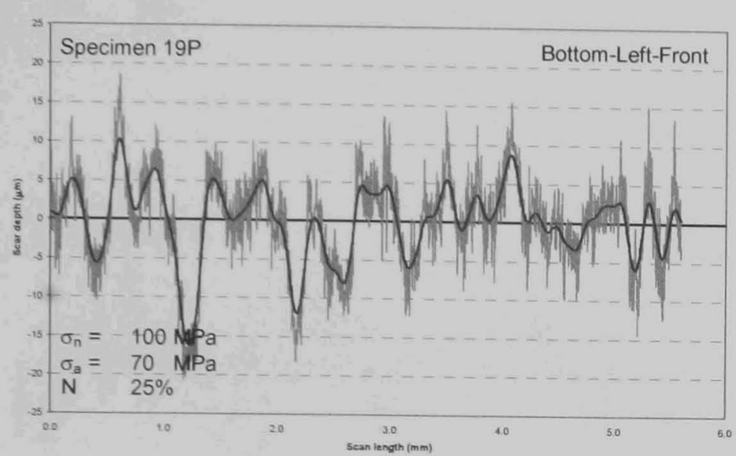

MAGNIFIED
Scan length (mm)
Scar depth (μm)

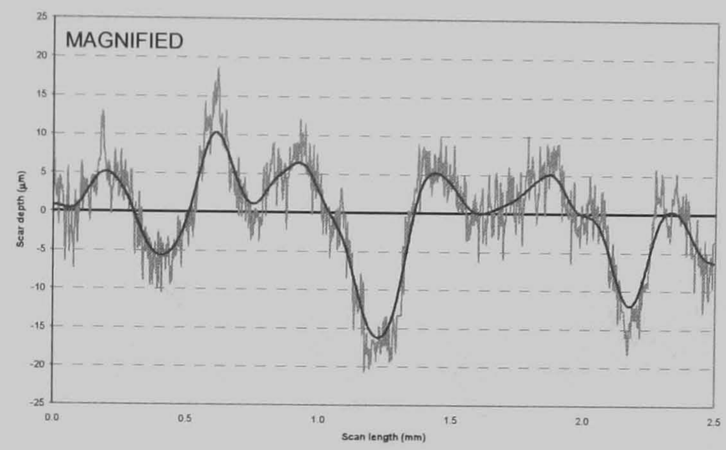

Specimen 14P
Top-Right-Middle
σ_n = 60 MPa
σ_a = 70 MPa
N 50%
Scan length (mm)
Scar depth (μm)

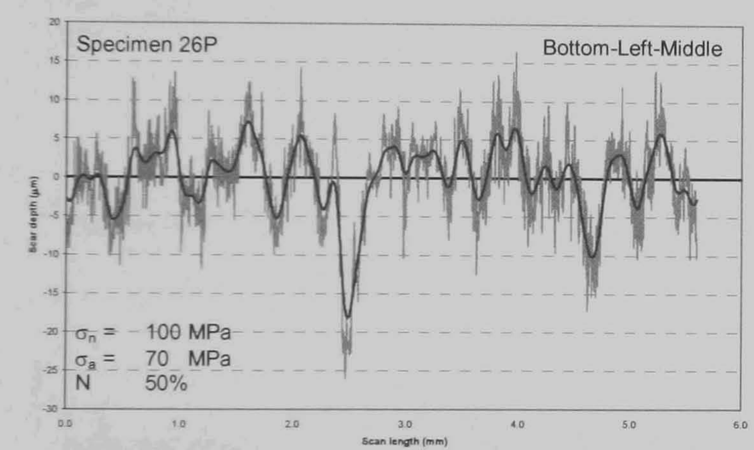

MAGNIFIED
Scan length (mm)
Scar depth (μm)

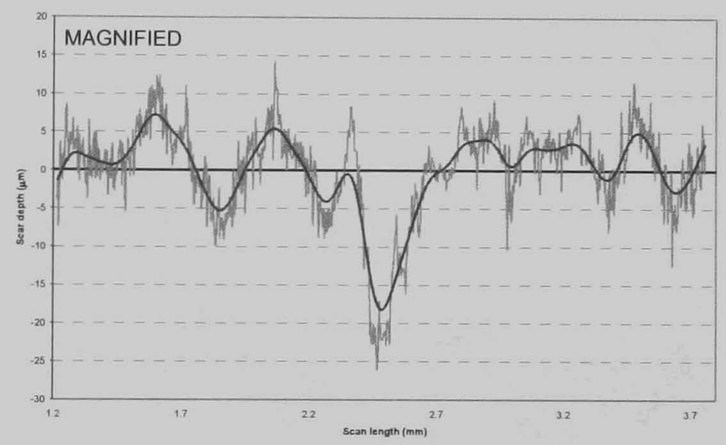

Specimen 43P
Bottom-Left-Middle
σ_n = 100 MPa
σ_a = 70 MPa
N 10%
Scar depth (μm)
Scan length (mm)

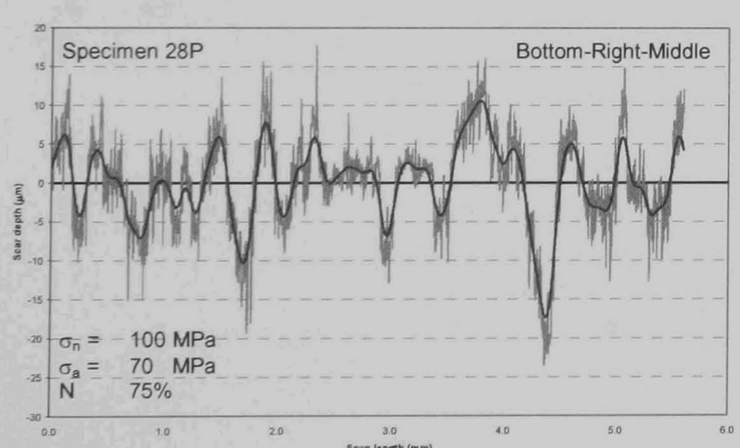

MAGNIFIED
Scar depth (μm)
Scan length (mm)

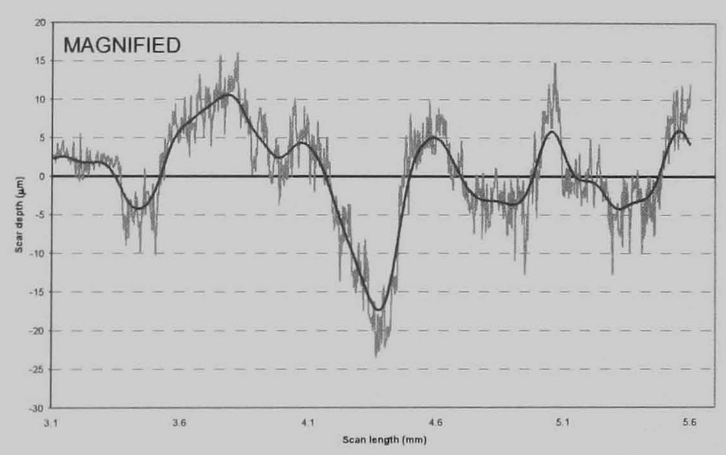

Specimen 19P
Bottom-Left-Front
σ_n = 100 MPa
σ_a = 70 MPa
N 25%
Scar depth (μm)
Scan length (mm)


MAGNIFIED
Scar depth (μm)
Scan length (mm)

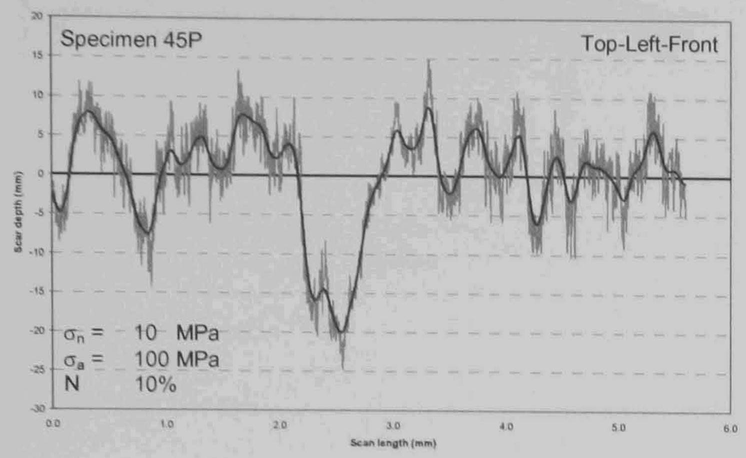

Specimen 26P
Bottom-Left-Middle
σ_n = 100 MPa
σ_a = 70 MPa
N 50%
Scar depth (μm)
Scan length (mm)

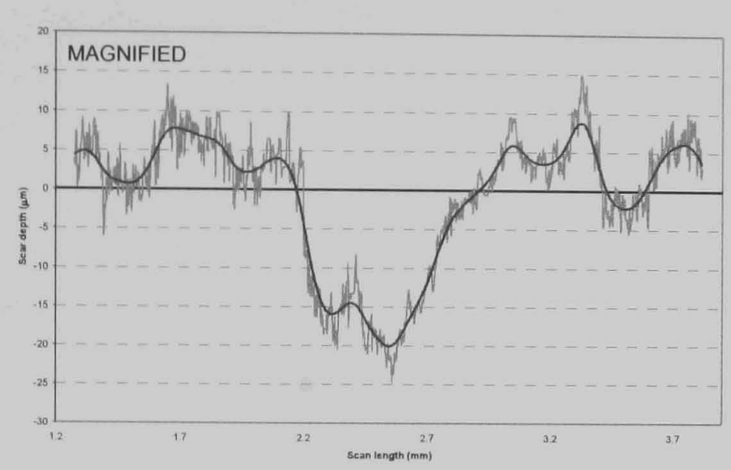

MAGNIFIED
Scar depth (μm)
Scan length (mm)

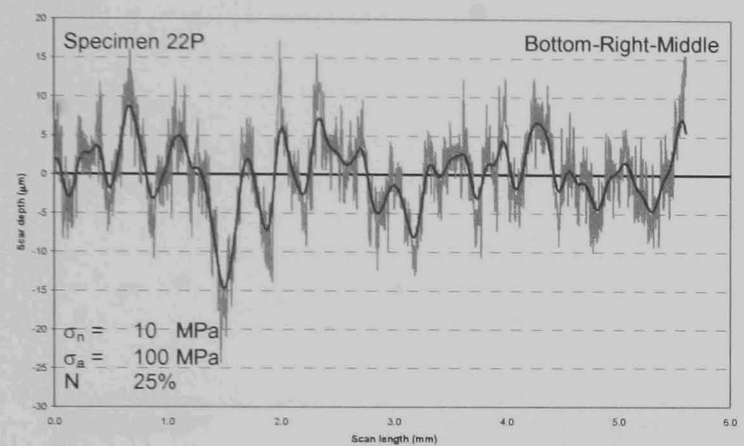

Specimen 28P
Bottom-Right-Middle
σ_n = 100 MPa
σ_a = 70 MPa
N 75%
Scar depth (μm)
Scan length (mm)

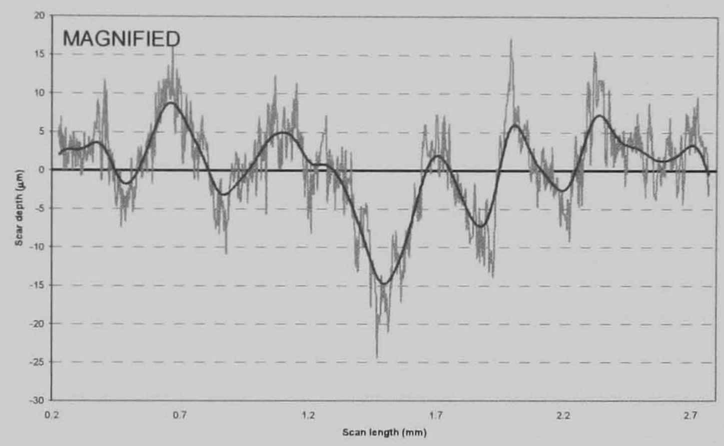

MAGNIFIED
Scar depth (μm)
Scan length (mm)

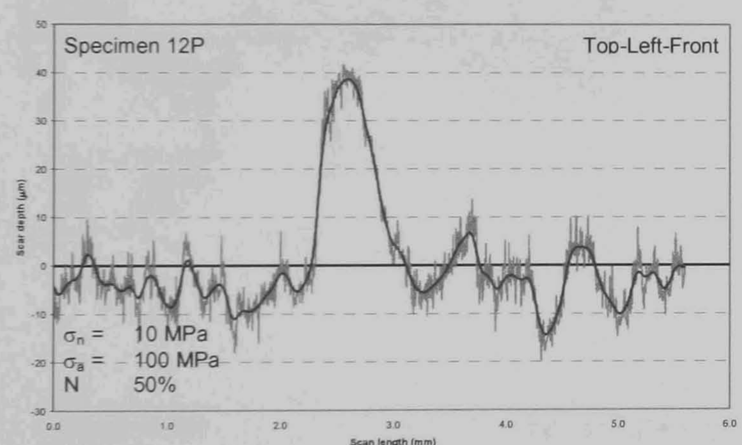
M.5 σ_a = 100 MPa peened

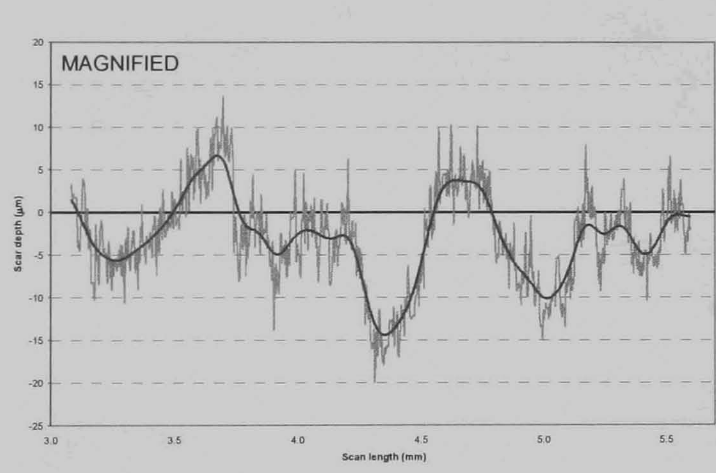


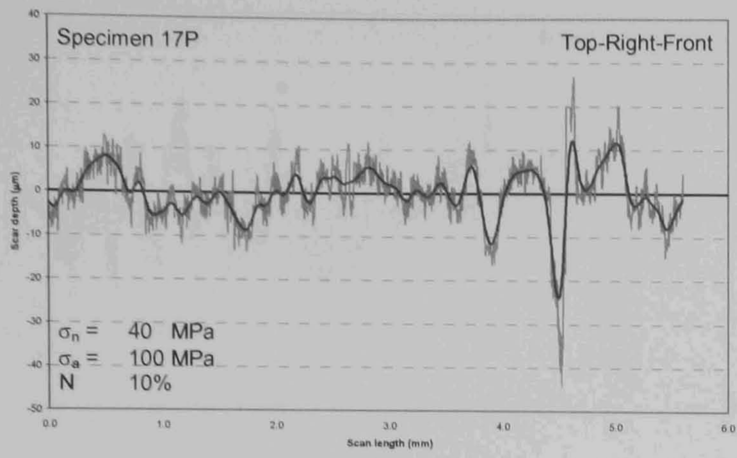


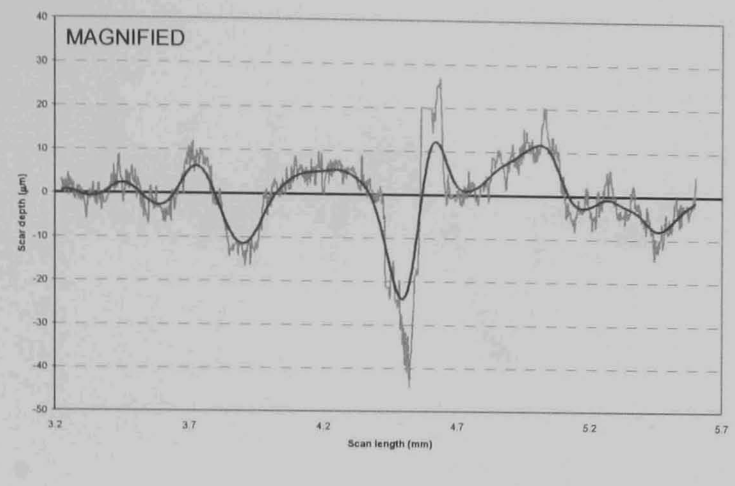


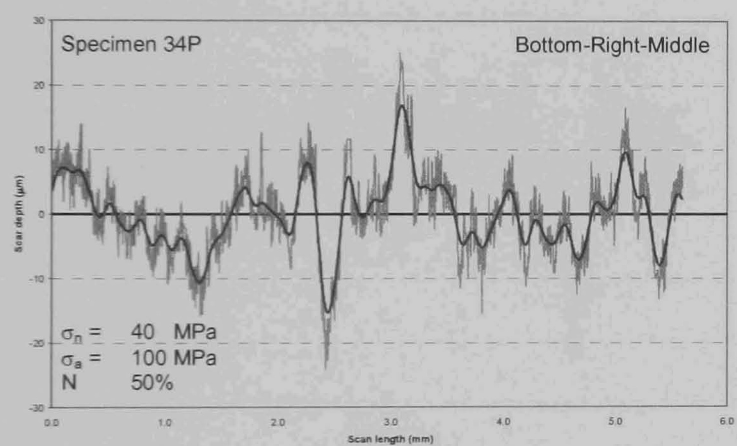


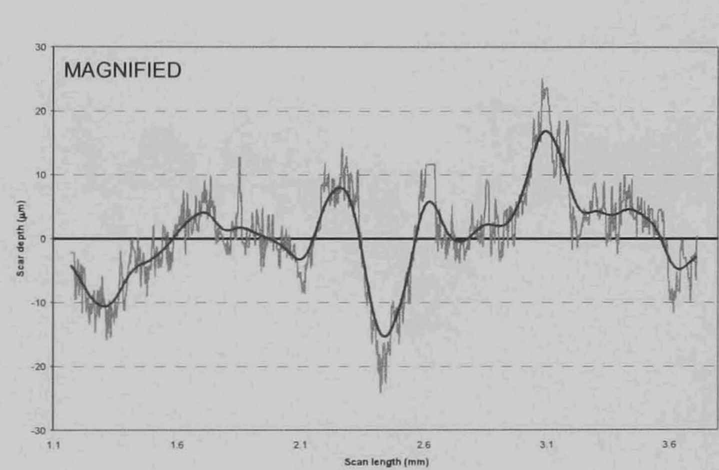


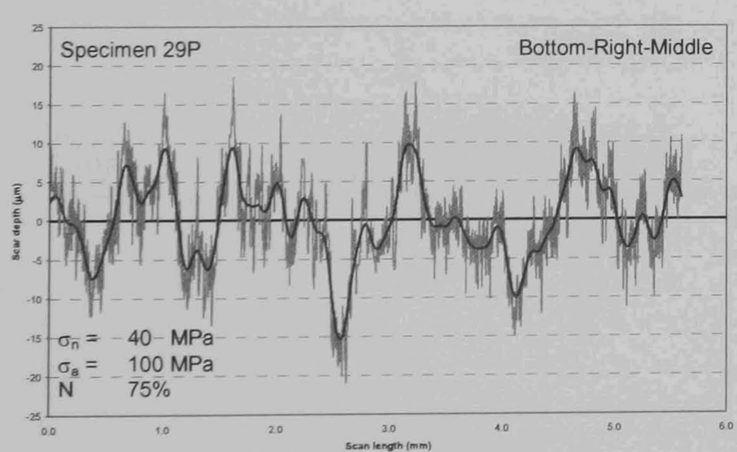


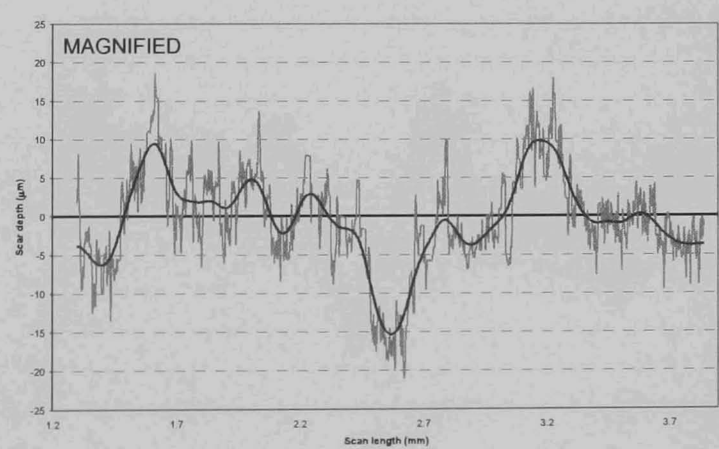

Specimen 17P
Top-Right-Front
σ_n = 40 MPa
σ_a = 100 MPa
N 10%
Scar depth (µm)
Scan length (mm)

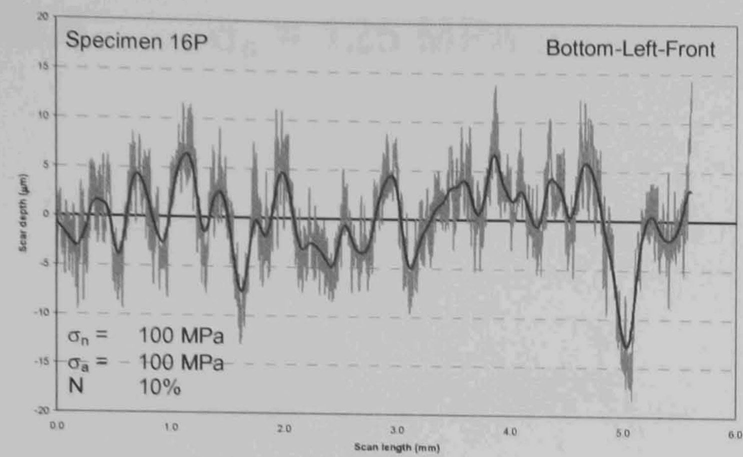

MAGNIFIED
Scar depth (µm)
Scan length (mm)

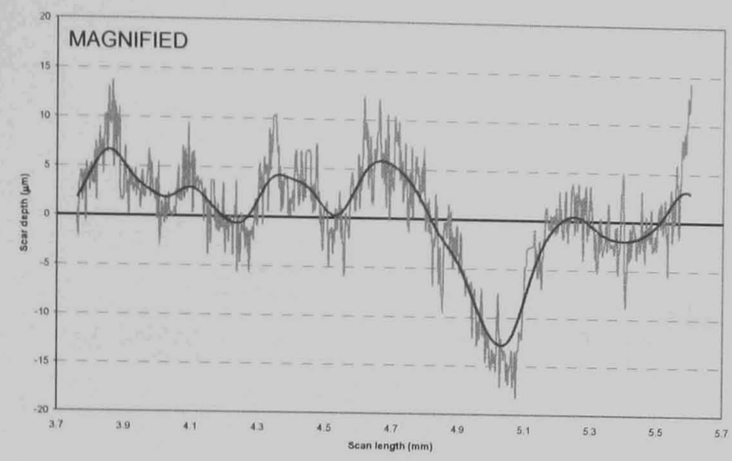

Specimen 34P
Bottom-Right-Middle
σ_n = 40 MPa
σ_a = 100 MPa
N 50%
Scar depth (µm)
Scan length (mm)

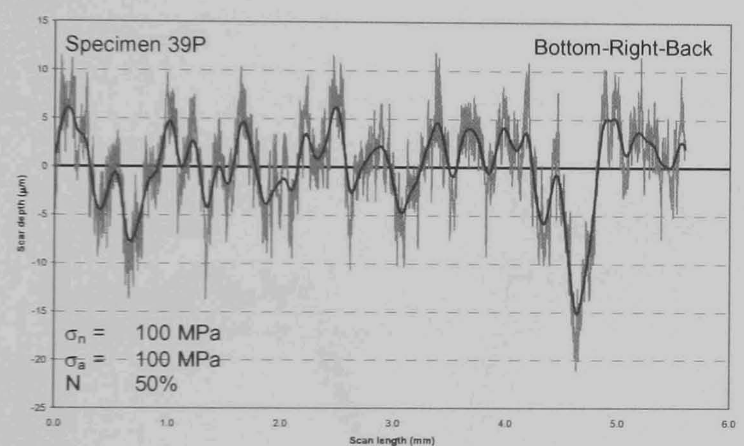

MAGNIFIED
Scar depth (µm)
Scan length (mm)

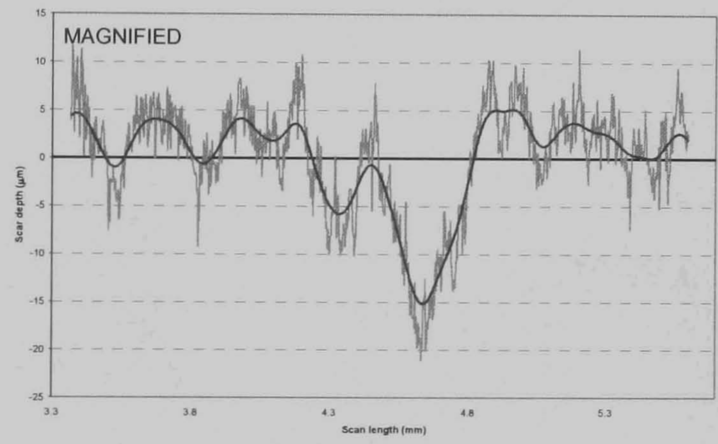

Specimen 29P
Bottom-Right-Middle
σ_n = 40 MPa
σ_a = 100 MPa
N 75%
Scar depth (µm)
Scan length (mm)

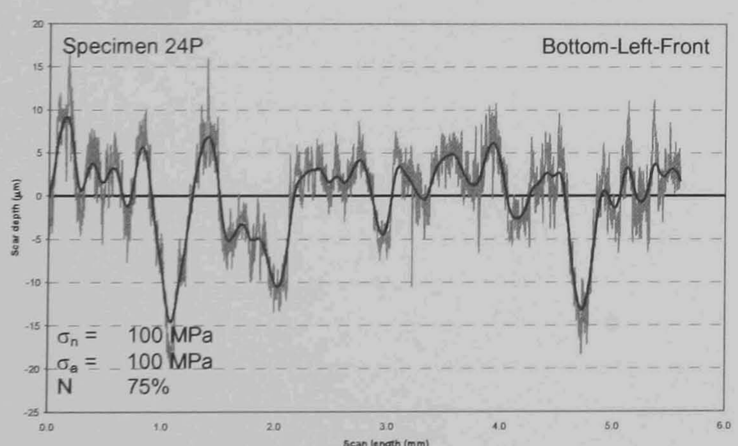

MAGNIFIED
Scar depth (µm)
Scan length (mm)

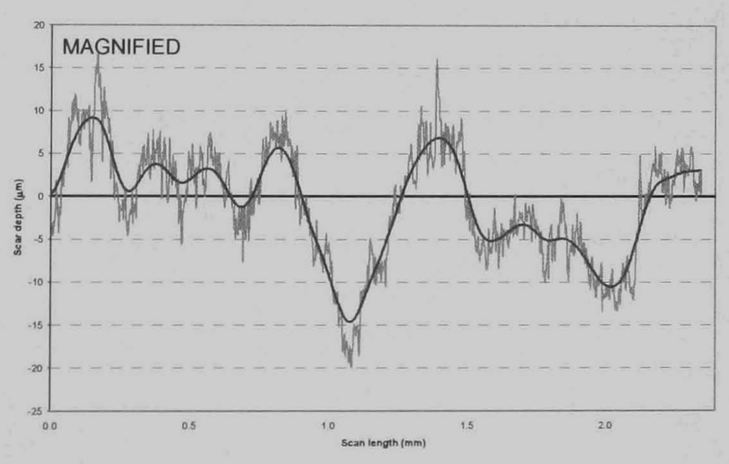

Specimen 16P
Bottom-Left-Front
σ_n = 100 MPa
σ_a = 100 MPa
N 10%
Scar depth (μm)
Scan length (mm)


MAGNIFIED
Scar depth (μm)
Scan length (mm)

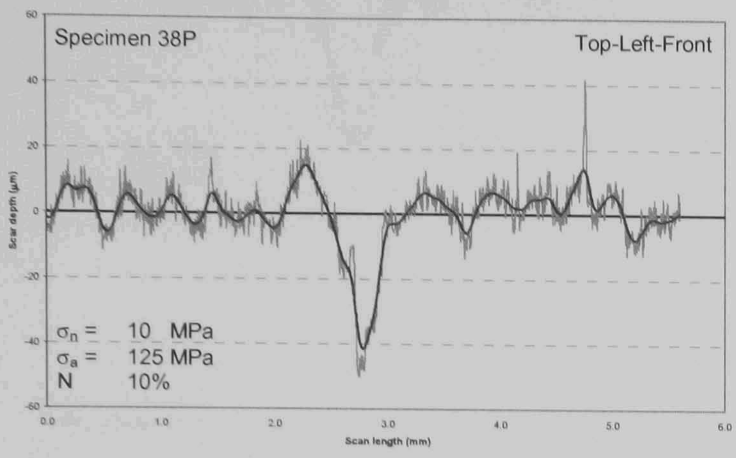

Specimen 39P
Bottom-Right-Back
σ_n = 100 MPa
σ_a = 100 MPa
N 50%
Scar depth (μm)
Scan length (mm)

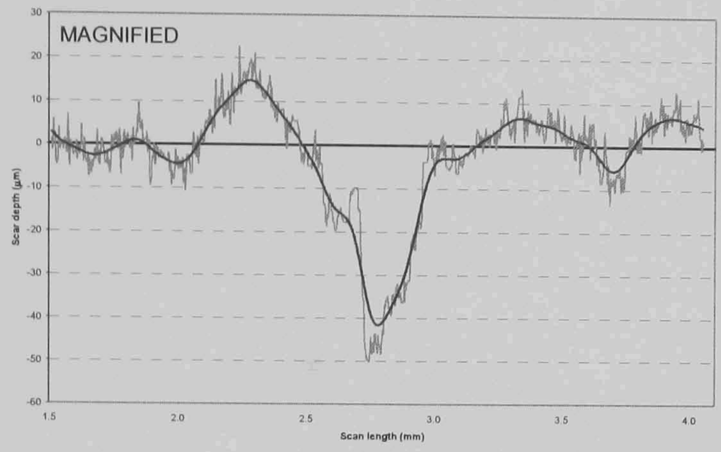

MAGNIFIED
Scar depth (μm)
Scan length (mm)

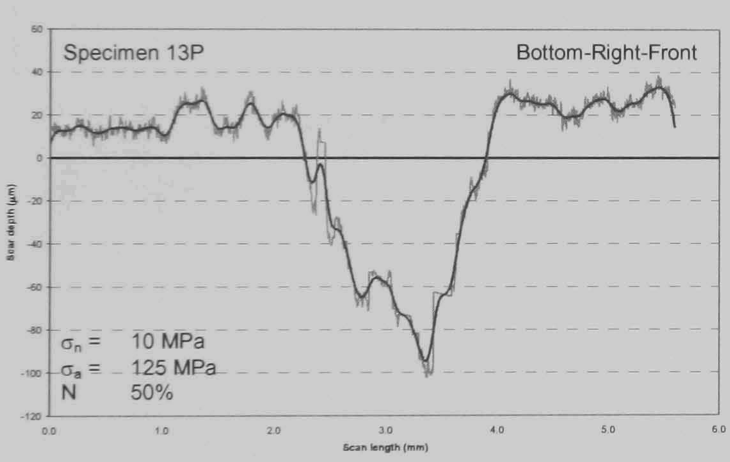

Specimen 24P
Bottom-Left-Front
σ_n = 100 MPa
σ_a = 100 MPa
N 75%
Scar depth (μm)
Scan length (mm)

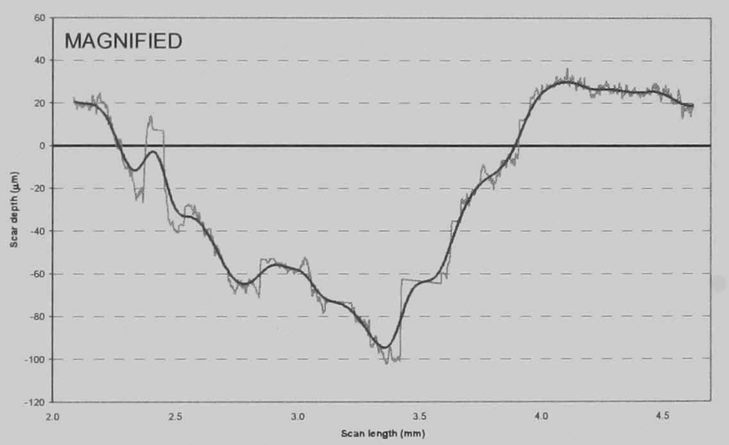

MAGNIFIED
Scar depth (μm)
Scan length (mm)

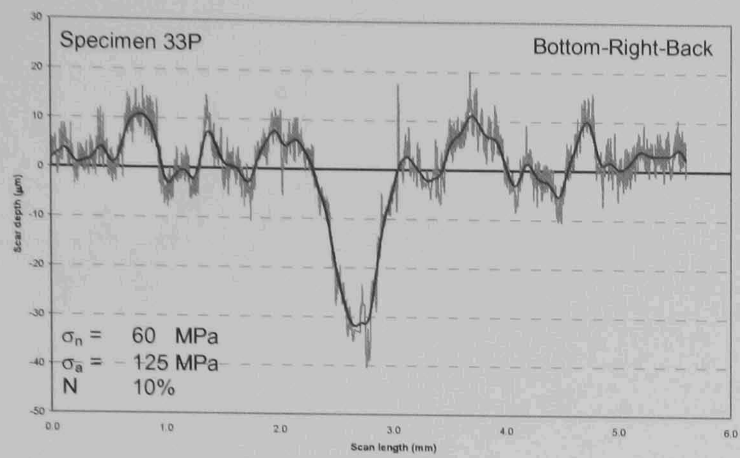
M.6 σ_a = 125 MPa peened

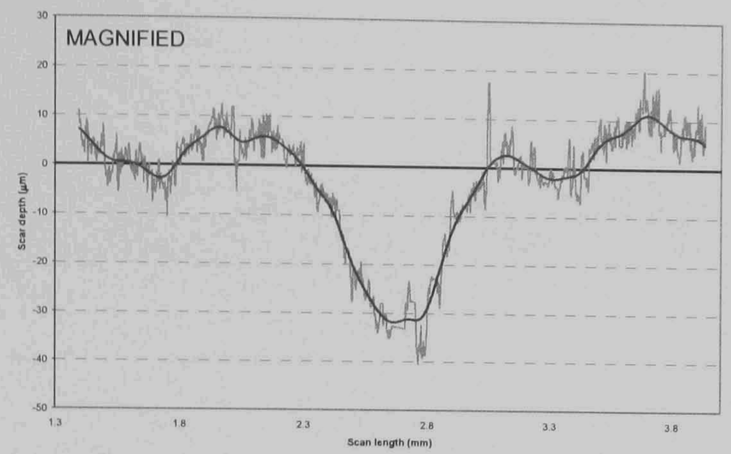


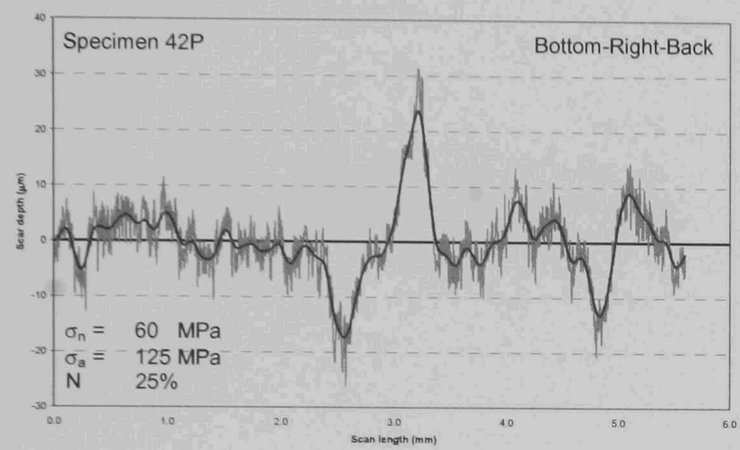


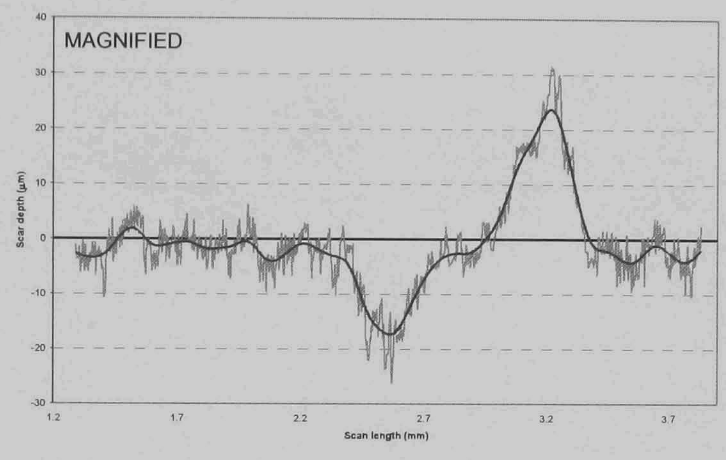


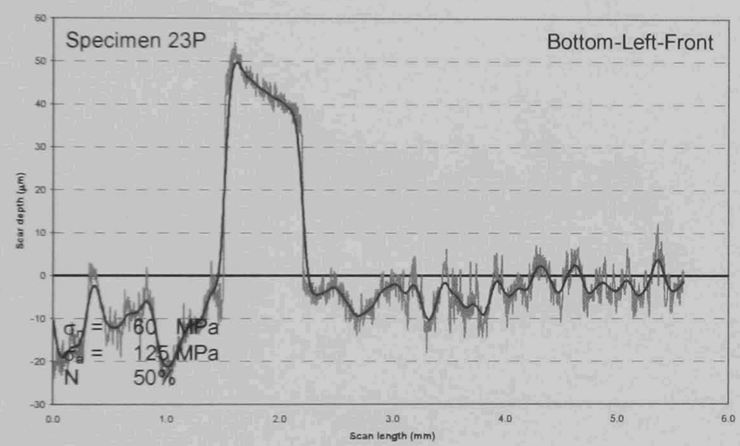


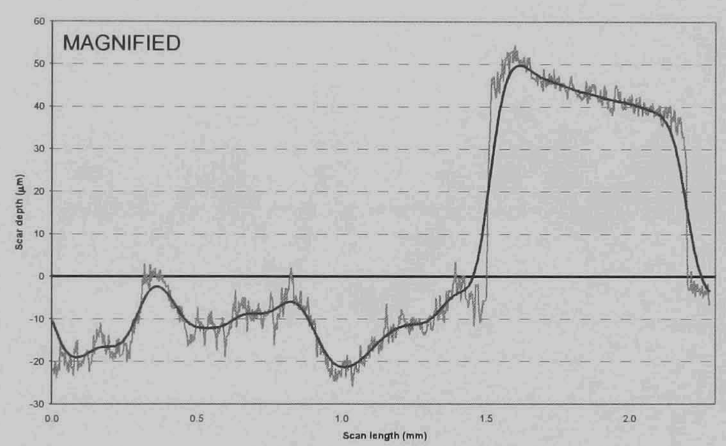

Specimen 33P
Bottom-Right-Back
σn = 60 MPa
σa = 125 MPa
N 10%
Scar depth (µm)
Scan length (mm)

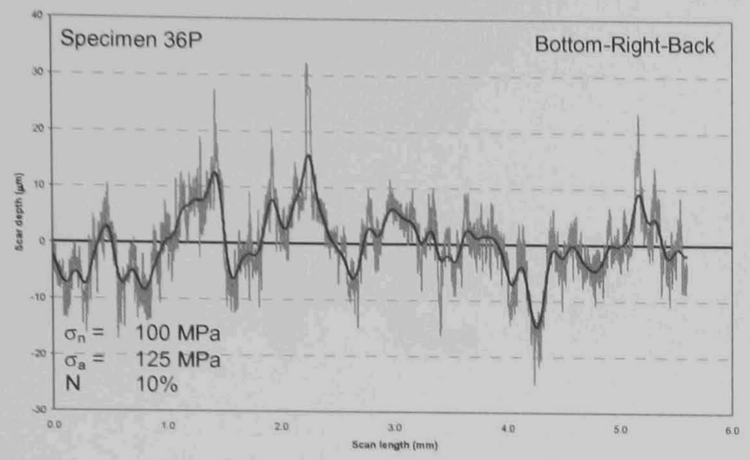

MAGNIFIED
Scar depth (µm)
Scan length (mm)

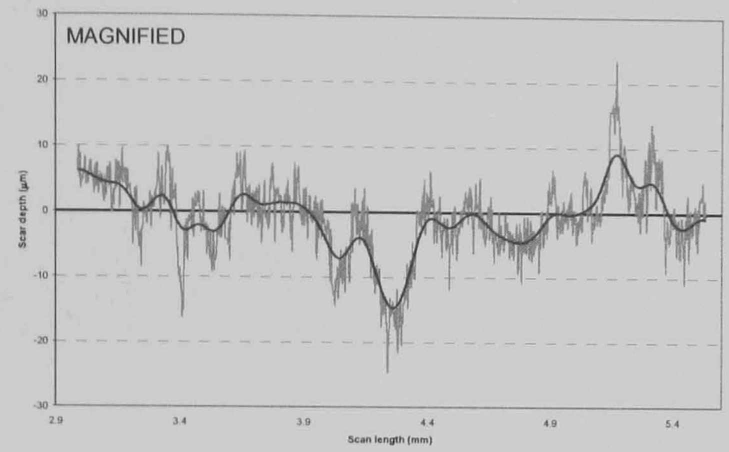

Specimen 42P
Bottom-Right-Back
σn = 60 MPa
σa = 125 MPa
N 25%
Scar depth (µm)
Scan length (mm)

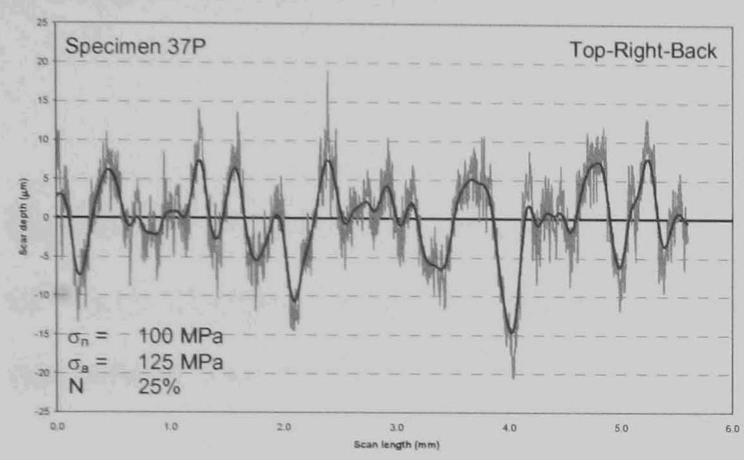

MAGNIFIED
Scar depth (µm)
Scan length (mm)

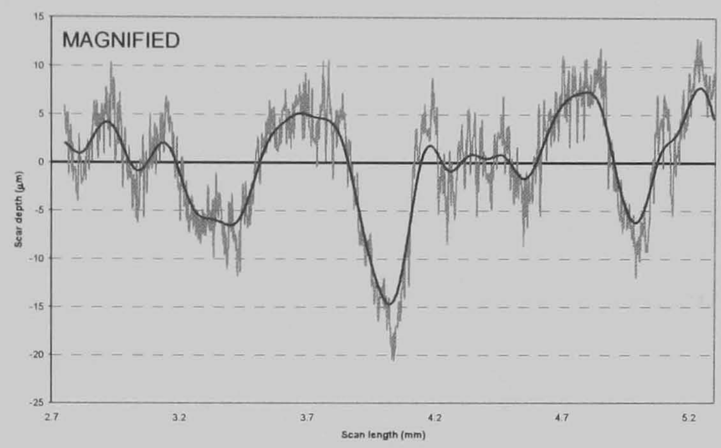

Specimen 23P
Bottom-Left-Front
σn = 60 MPa
σa = 125 MPa
N 50%
Scar depth (µm)
Scan length (mm)

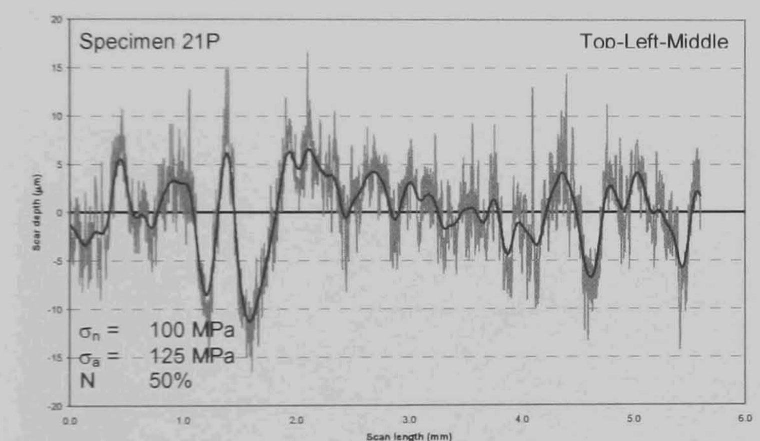

MAGNIFIED
Scar depth (µm)
Scan length (mm)

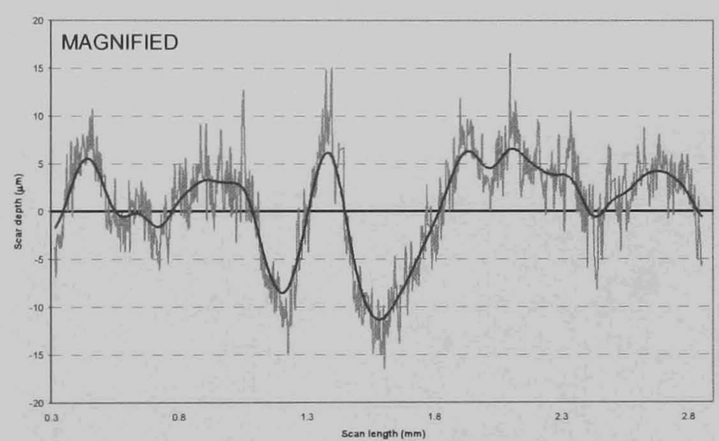

Specimen 36P
Bottom-Right-Back
σn = 100 MPa
σa = 125 MPa
N 10%
Scar depth (μm)
Scan length (mm)


MAGNIFIED
Scar depth (μm)
Scan length (mm)


Specimen 37P
Top-Right-Back
σn = 100 MPa
σa = 125 MPa
N 25%
Scar depth (μm)
Scan length (mm)


MAGNIFIED
Scar depth (μm)
Scan length (mm)


Specimen 21P
Top-Left-Middle
σn = 100 MPa
σa = 125 MPa
N 50%
Scar depth (μm)
Scan length (mm)

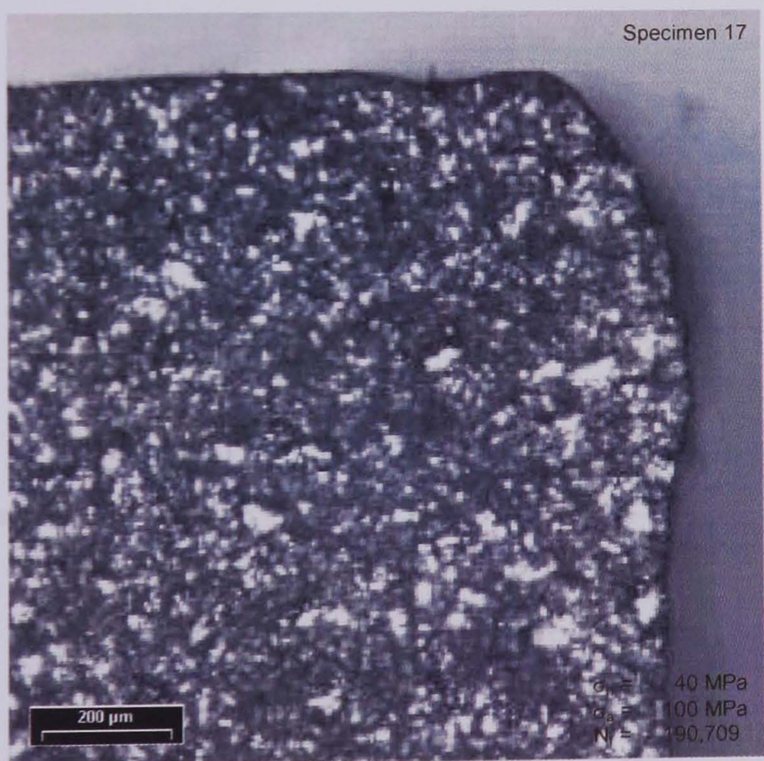

MAGNIFIED
Scar depth (μm)
Scan length (mm)

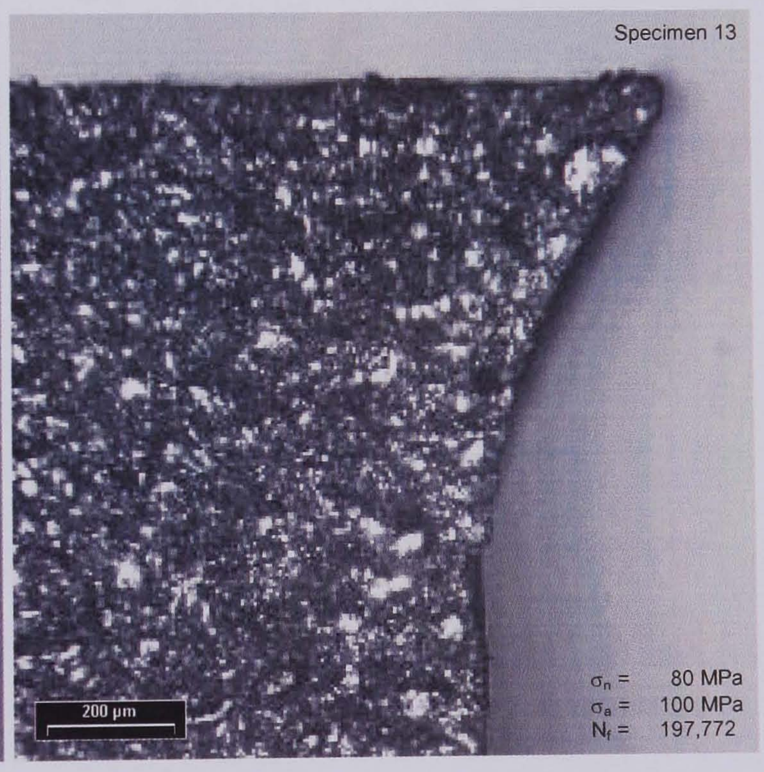
APPENDIX N

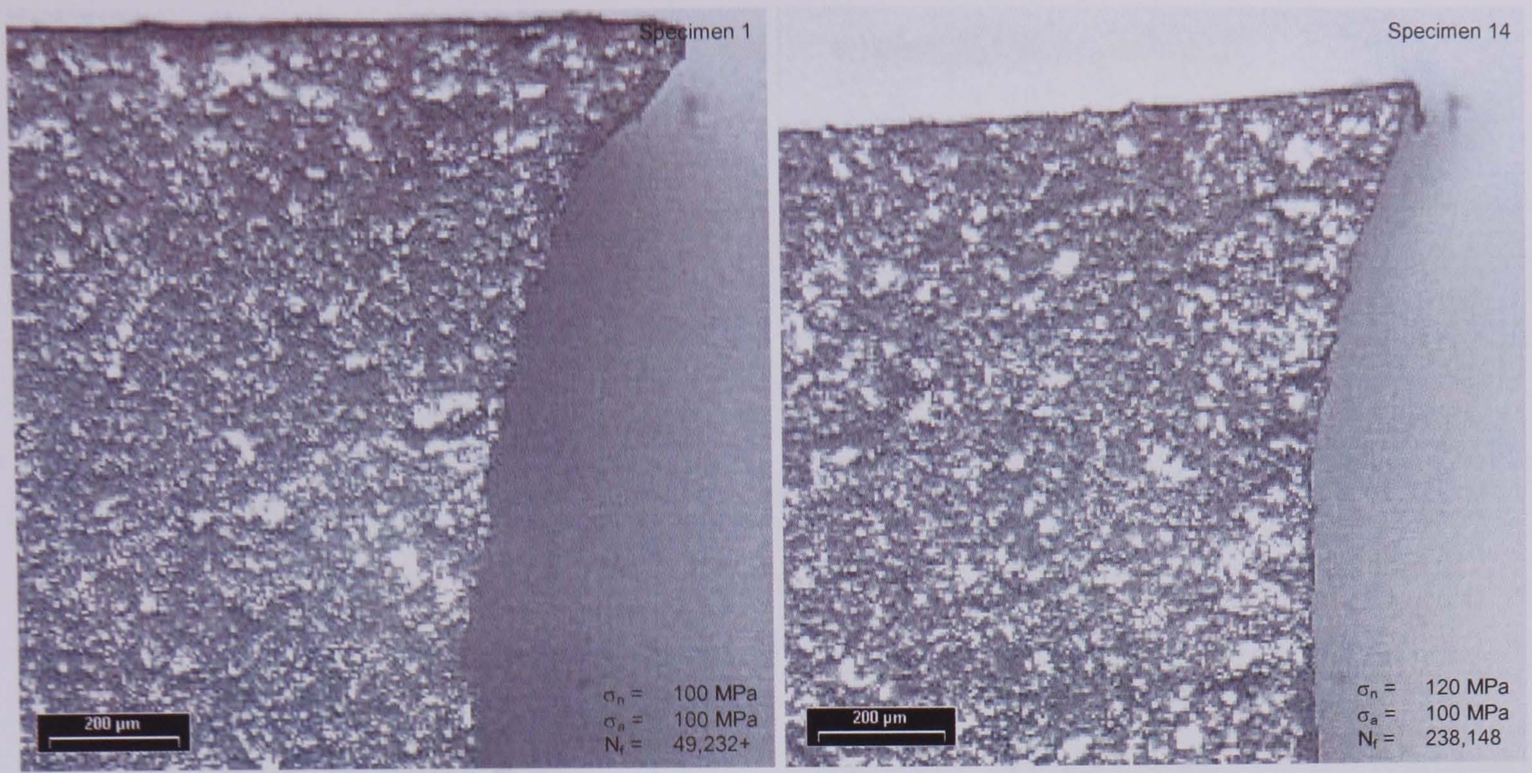
RESULTS: CRACK ANGLES

Sectioned, fractured fretting specimens, orientated with a fretting scar at the top of each image. Stage I, angled crack growth, and Stage II propagation nearly normal to the surface is demonstrated, see Section 4.4.2.

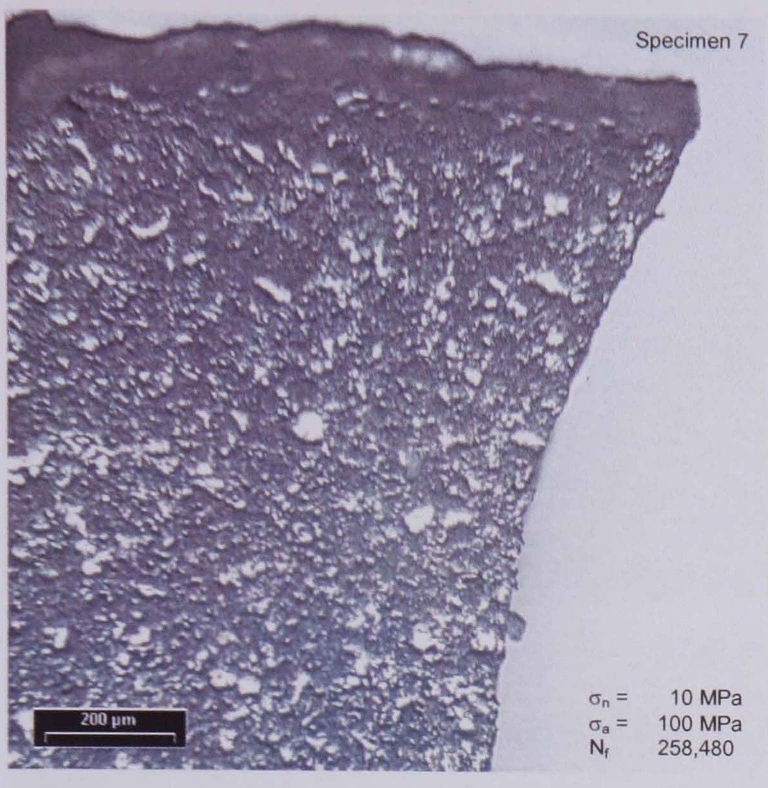
N.2 σ_a = 100 MPa unpeened – steel bridge

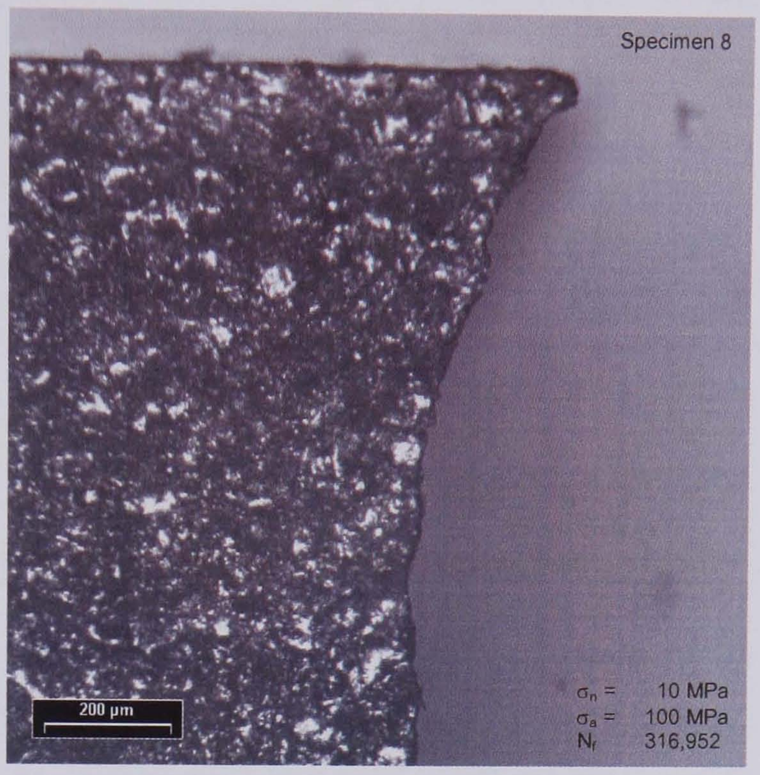


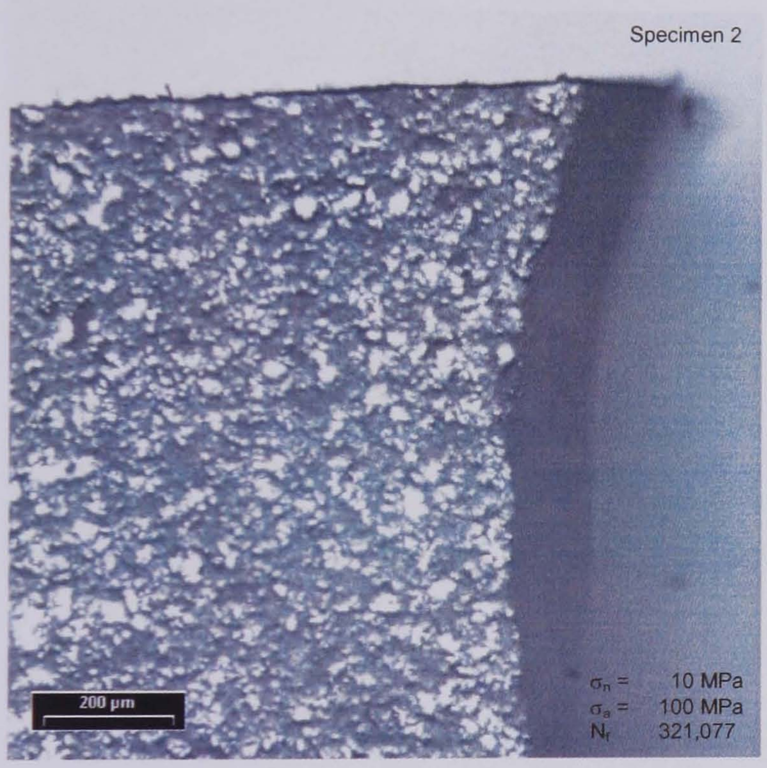


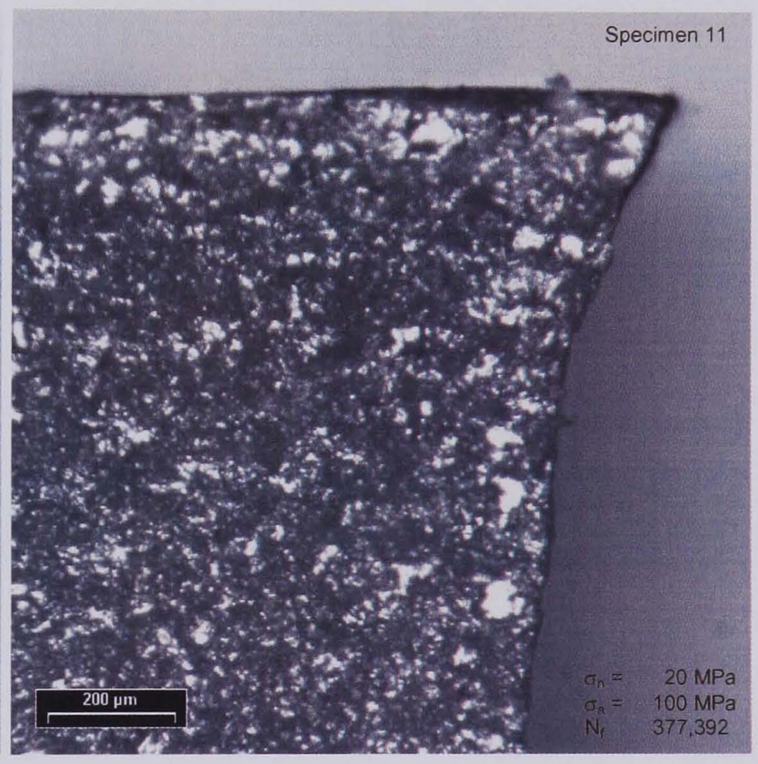

Specimen 1
200 µm
σn = 100 MPa
σa = 100 MPa
Nf = 49,232+
Specimen 14
200 µm
σn = 120 MPa
σa = 100 MPa
Nf = 238,148

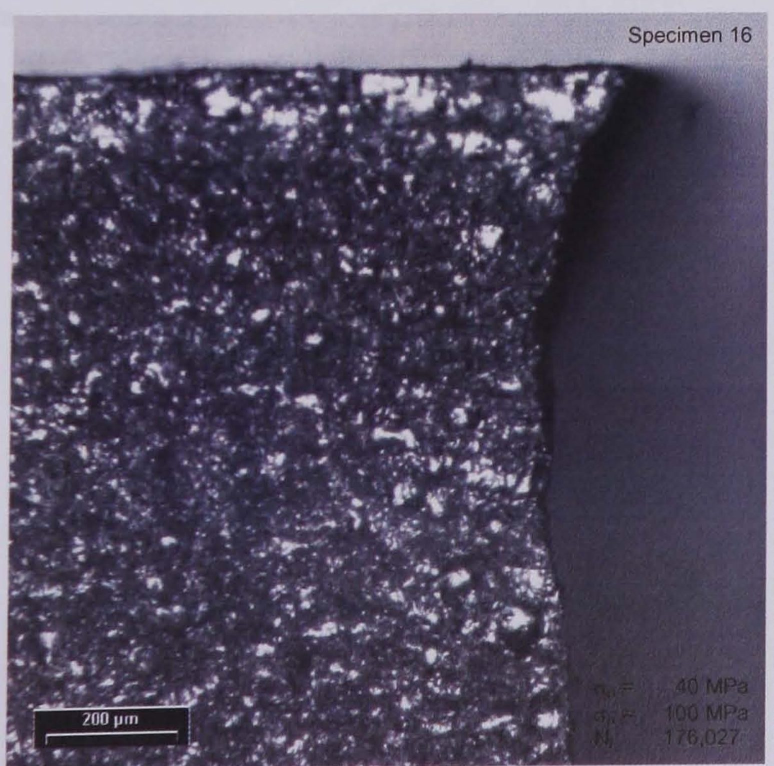
N.2 σ_a = 100 MPa unpeened – aluminium bridge

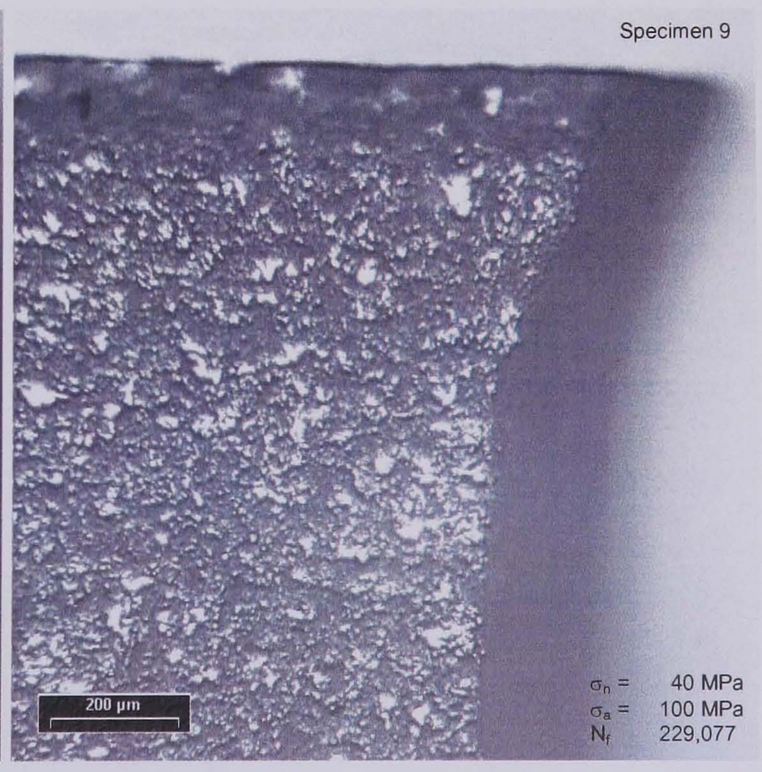


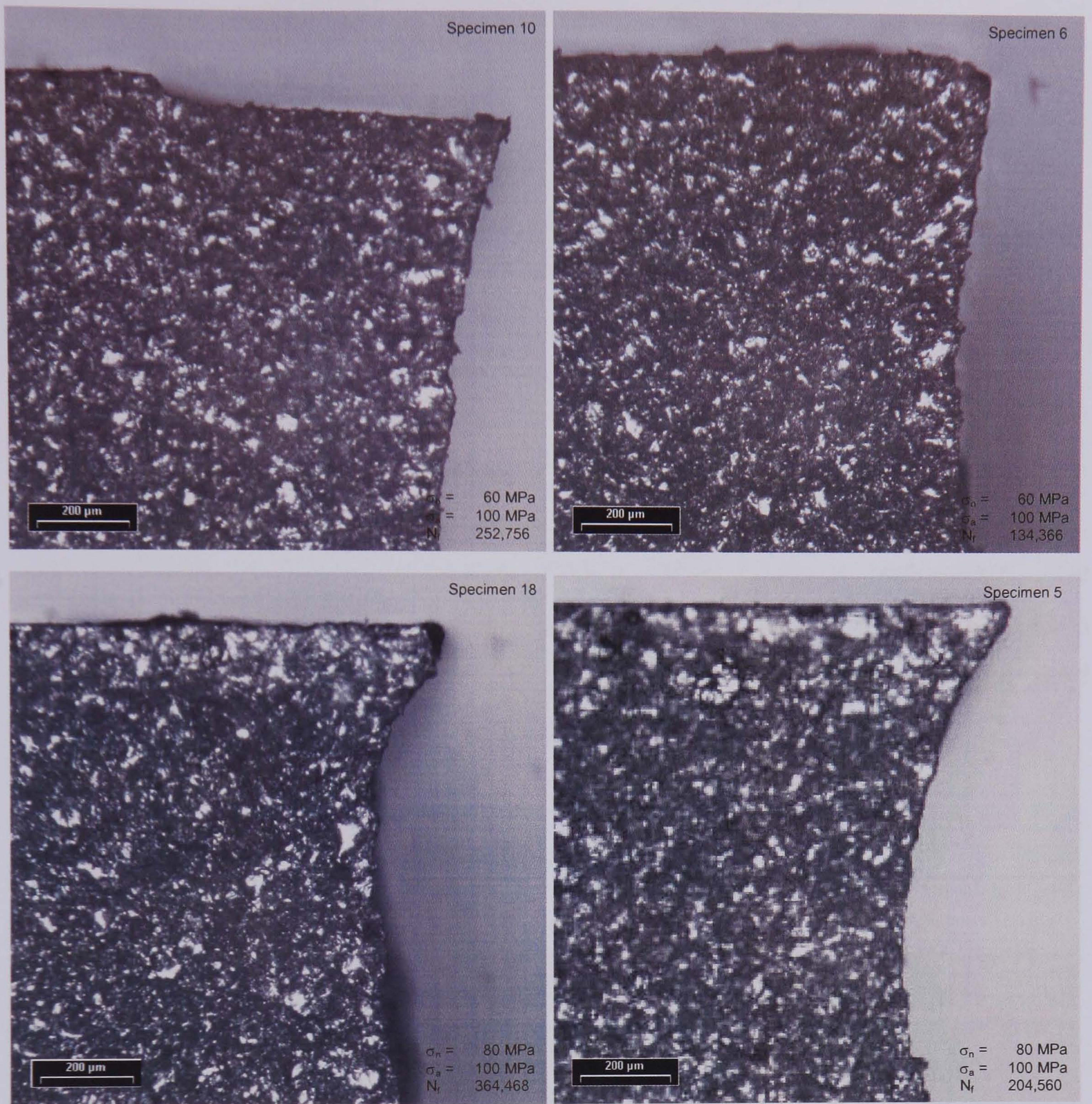










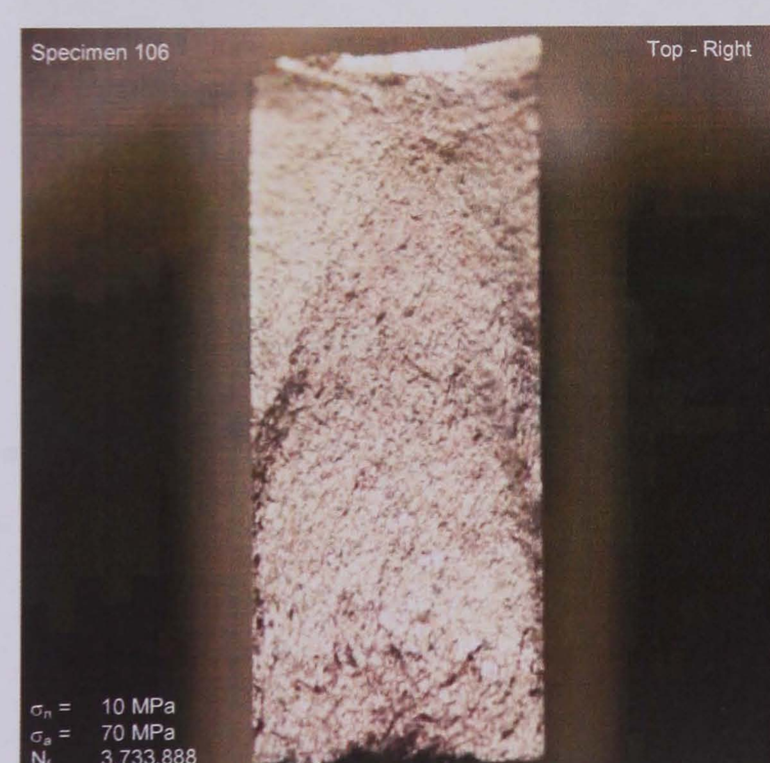

Specimen 10
200 µm
60 MPa
100 MPa
252,756
Specimen 6
200 µm
σn = 60 MPa
σa = 100 MPa
Nf 134,366
Specimen 18
200 µm
σn = 80 MPa
σa = 100 MPa
Nf 364,468
Specimen 5
200 µm
σn = 80 MPa
σa = 100 MPa
Nf 204,560

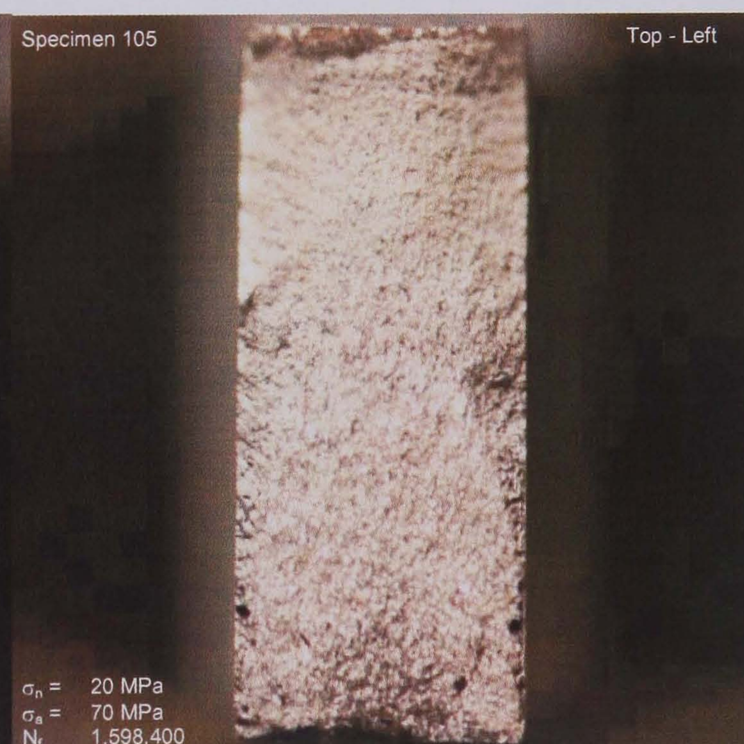
APPENDIX O

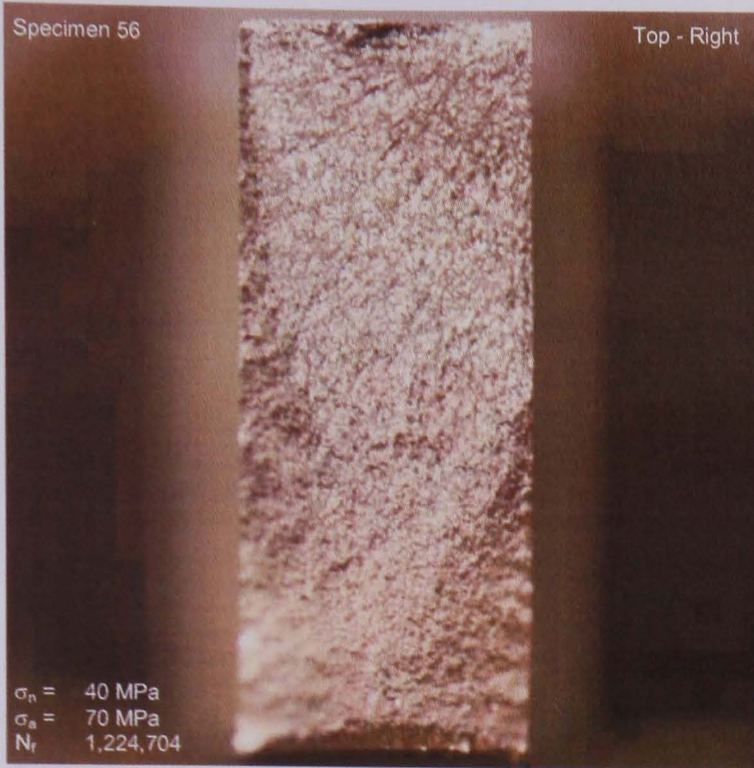
RESULTS: FRACTURE SURFACES

This appendix contains digital photographs of the fractured specimens. The label in the top right hand corner denotes the orientation of the fracture surface and the location of the main failure site, be it having initiated from the right hand or left hand scar. These specimens are of a cross section 8 x 20 mm.

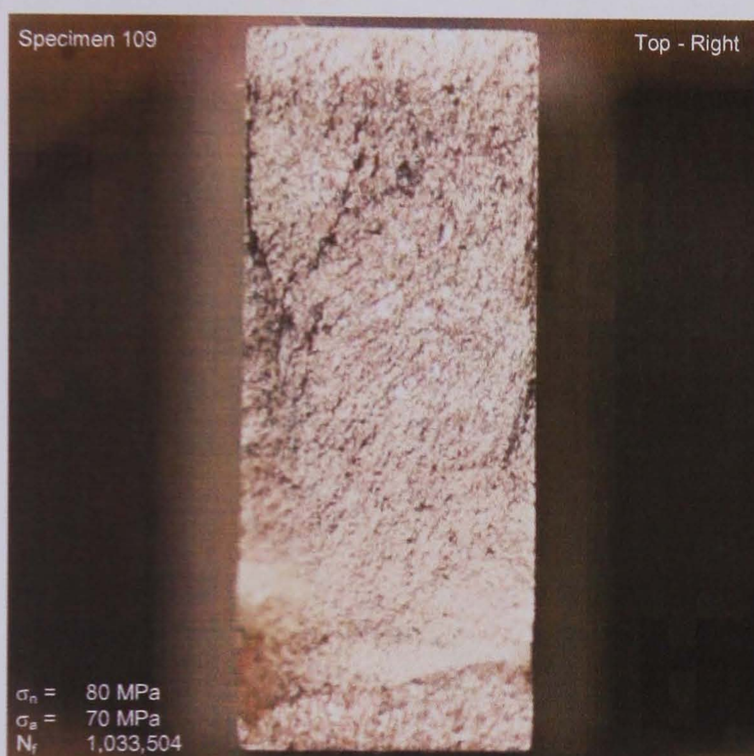
O.1 σ_a = 70 MPa unpeened

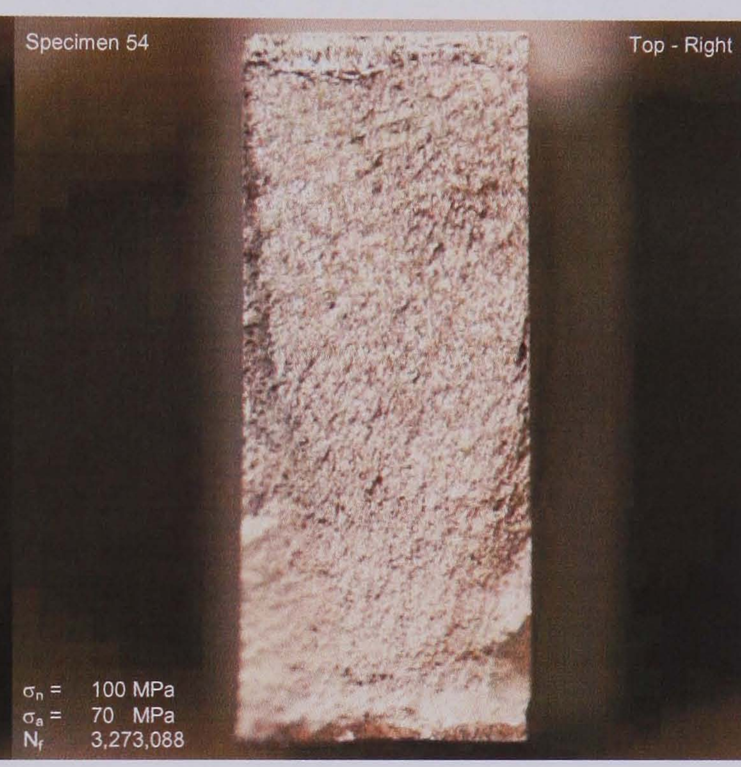




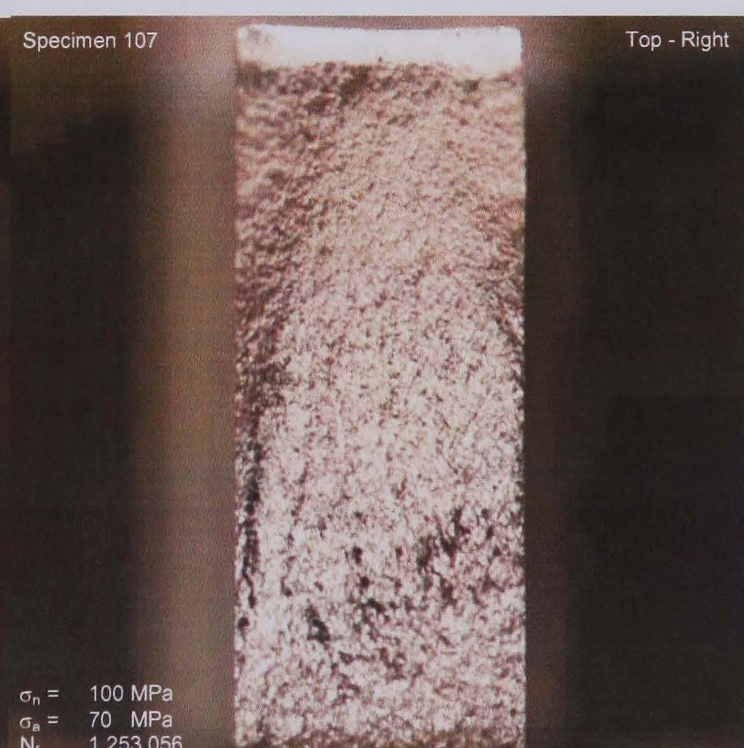

Specimen 56
Top - Right
σ_n = 40 MPa
σ_a = 70 MPa
N_f 1,224,704


Specimen 59
Top - Right
σ_n = 60 MPa
σ_a = 70 MPa
N_f 886,320

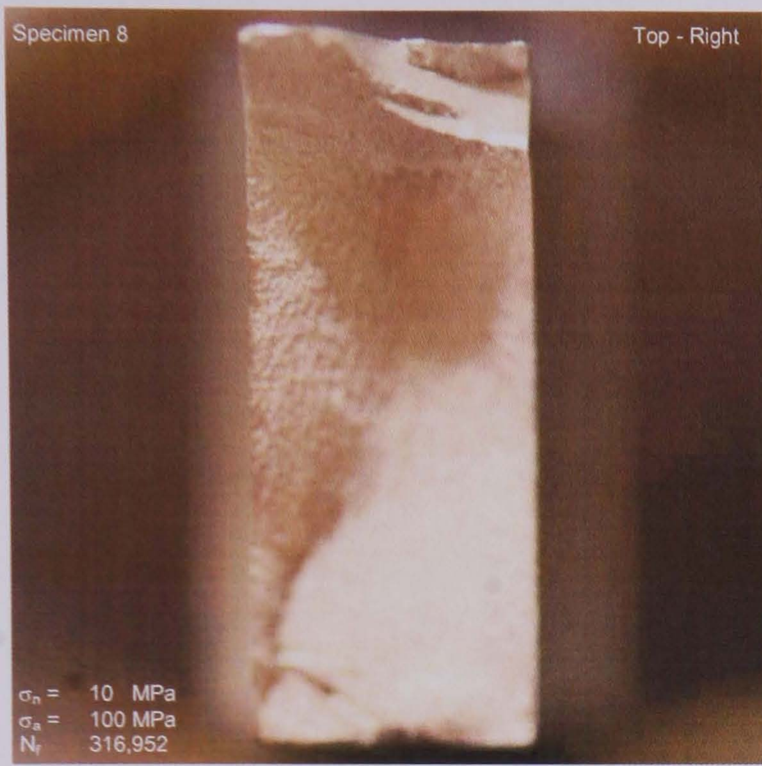

Specimen 109
Top - Right
σ_n = 80 MPa
σ_a = 70 MPa
N_f 1,033,504

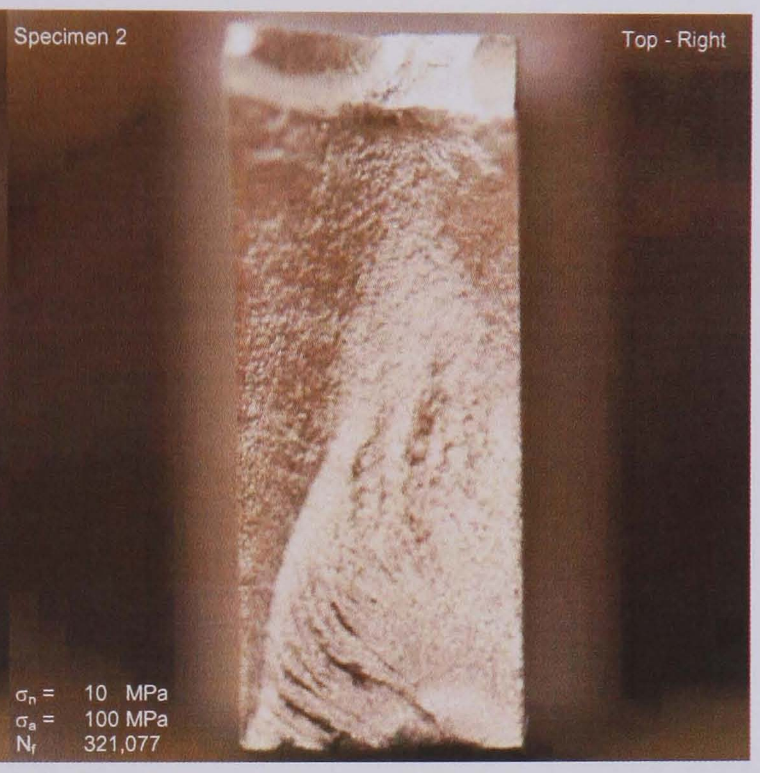

Specimen 54
Top - Right
σ_n = 100 MPa
σ_a = 70 MPa
N_f 3,273,088

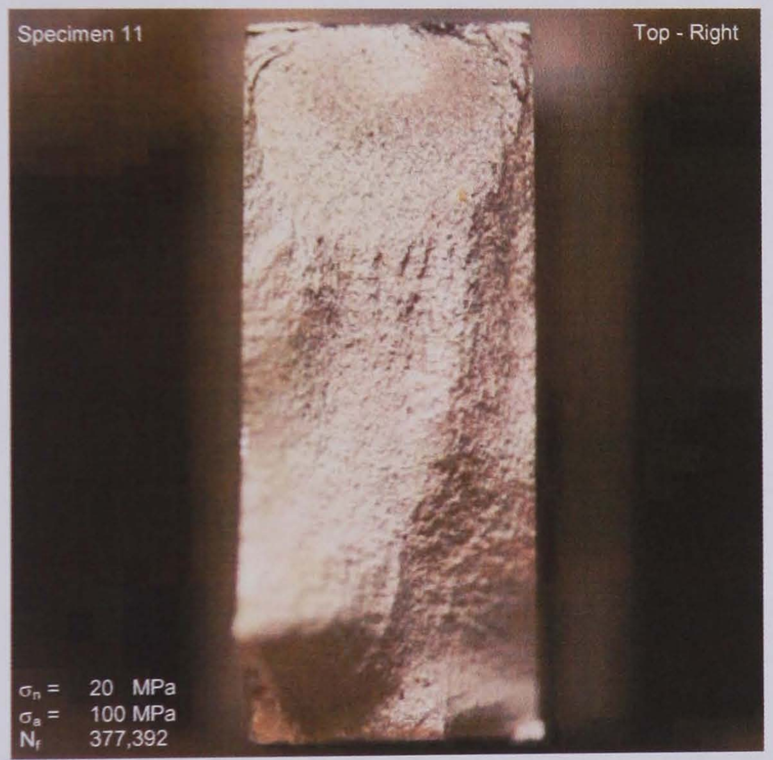

Specimen 104
Top - Left
σ_n = 100 MPa
σ_a = 70 MPa
N_f 1,741,888


Specimen 107
Top - Right
σ_n = 100 MPa
σ_a = 70 MPa
N_f 1,253,056

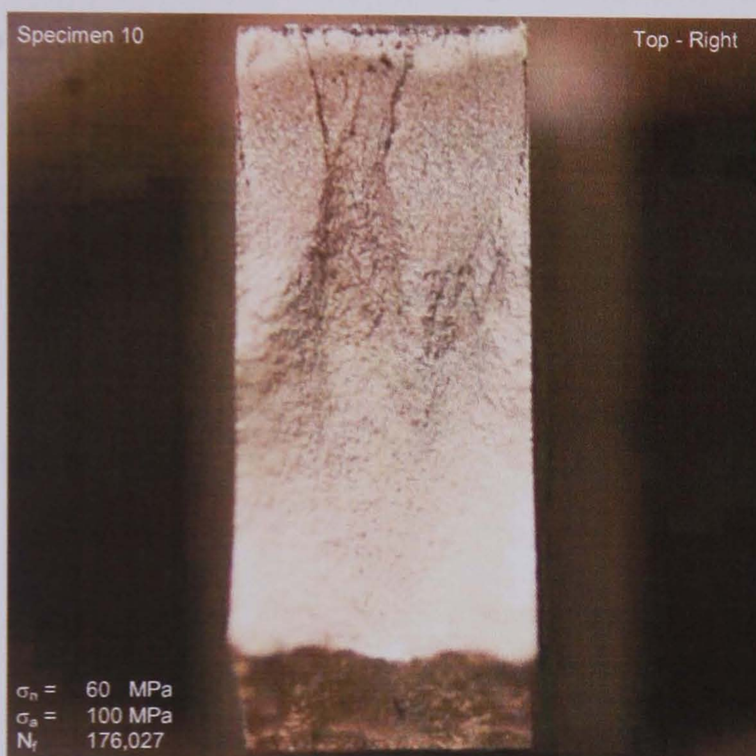
O.2 σ_a = 100 MPa unpeened

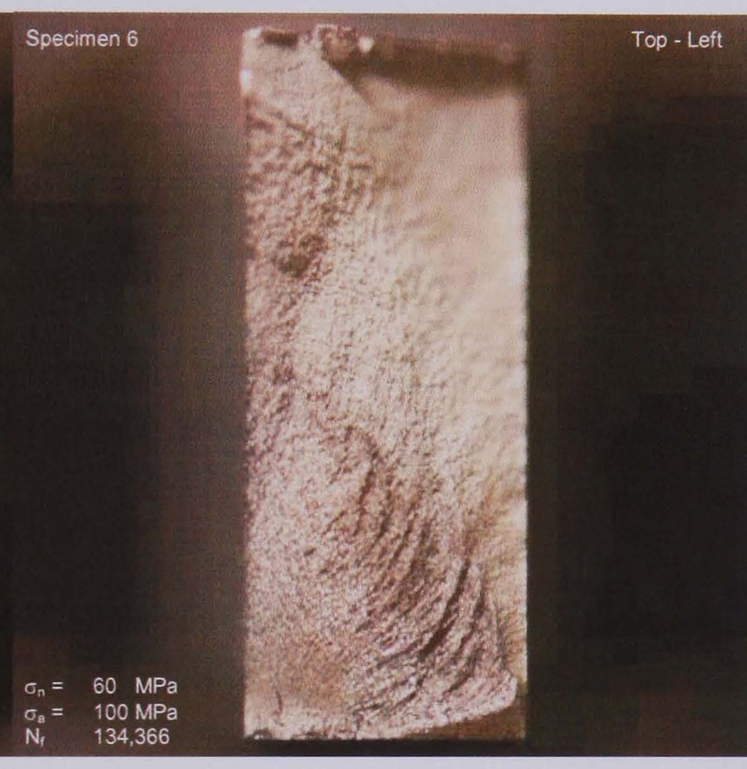


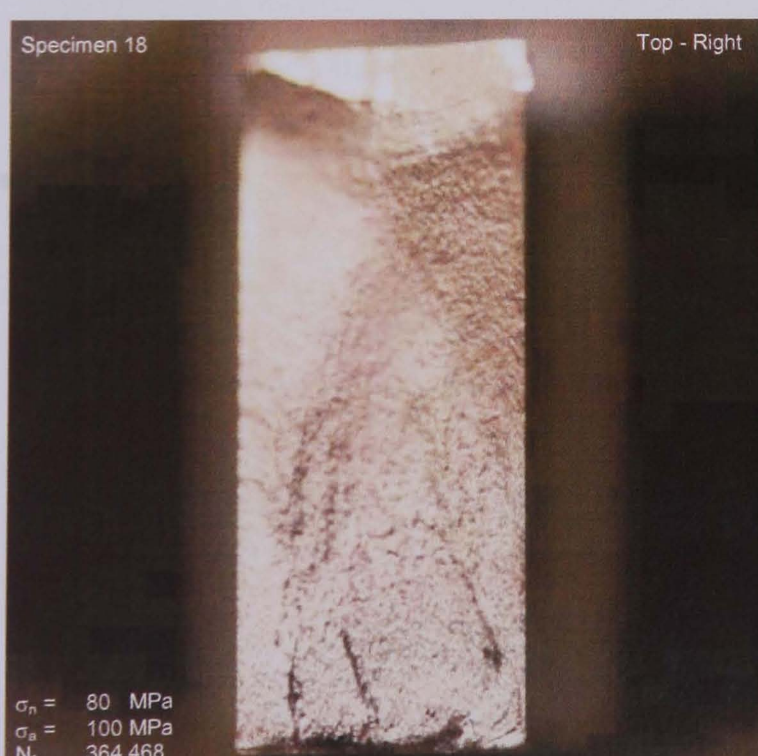


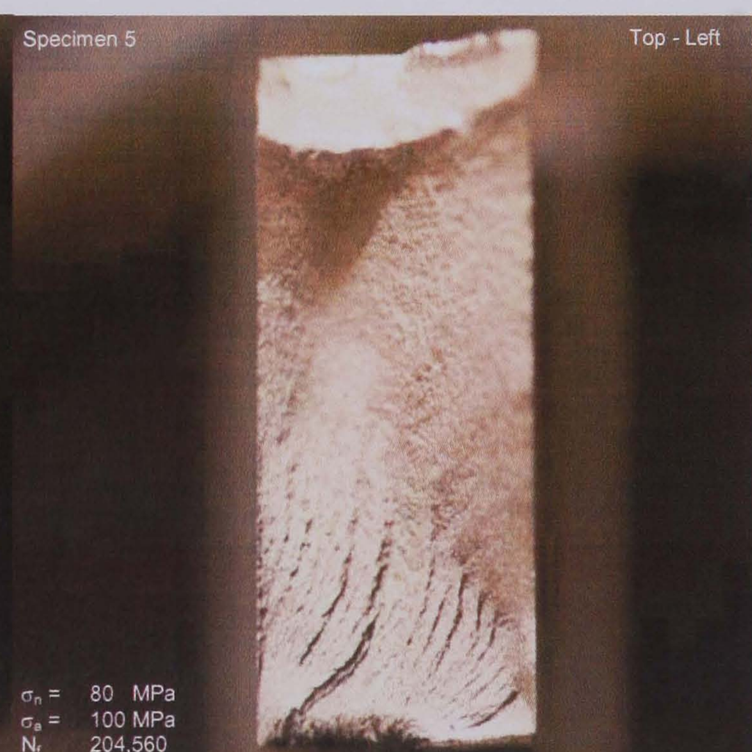


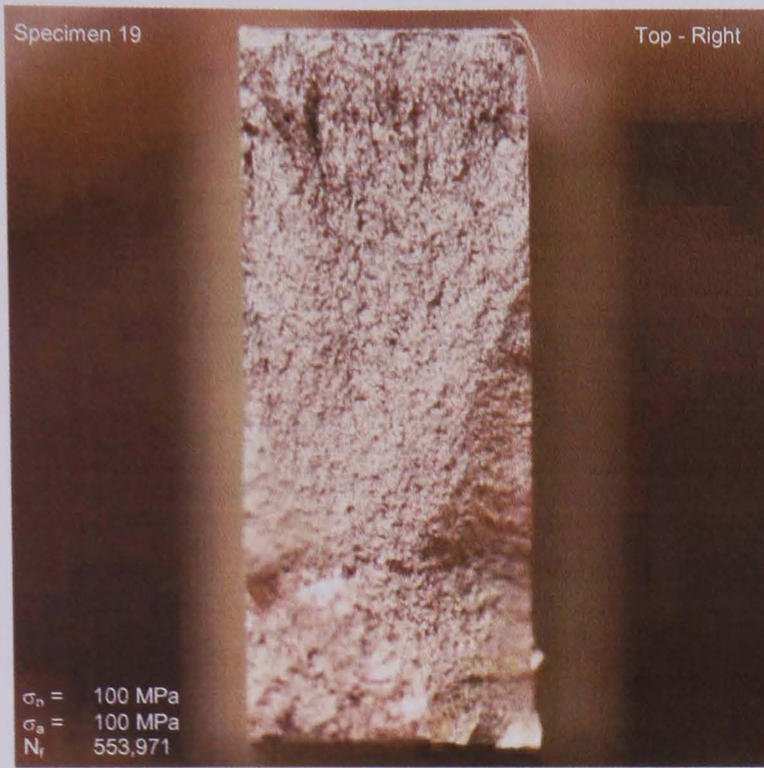

Specimen 9
Top - Left
σ_n = 40 MPa
σ_a = 100 MPa
N_f 229,077


Specimen 10
Top - Right
σ_n = 60 MPa
σ_a = 100 MPa
N_f 176,027

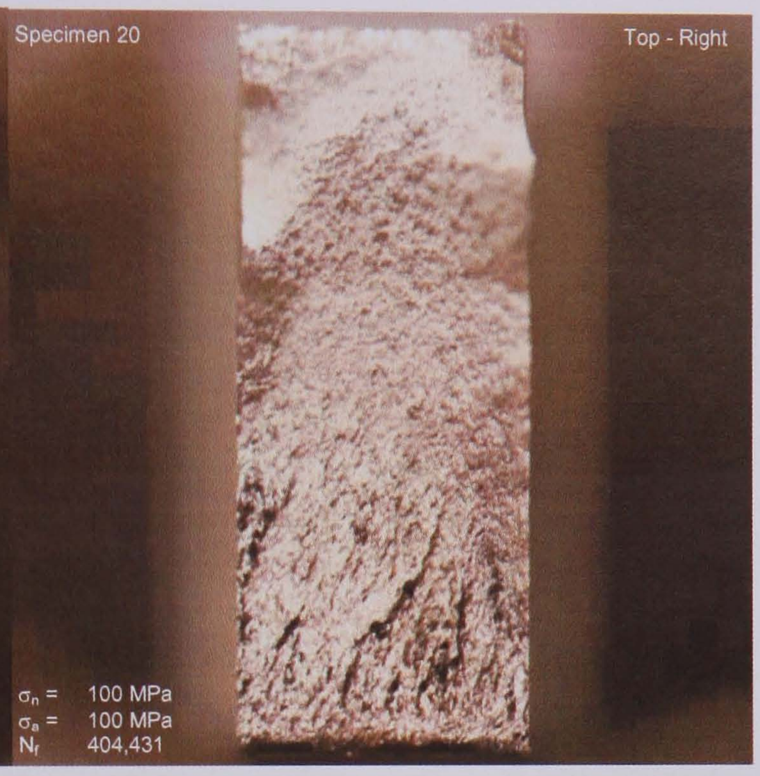

Specimen 6
Top - Left
σ_n = 60 MPa
σ_a = 100 MPa
N_f 134,366


Specimen 18
Top - Right
σ_n = 80 MPa
σ_a = 100 MPa
N_f 364,468


Specimen 5
Top - Left
σ_n = 80 MPa
σ_a = 100 MPa
N_f 204,560

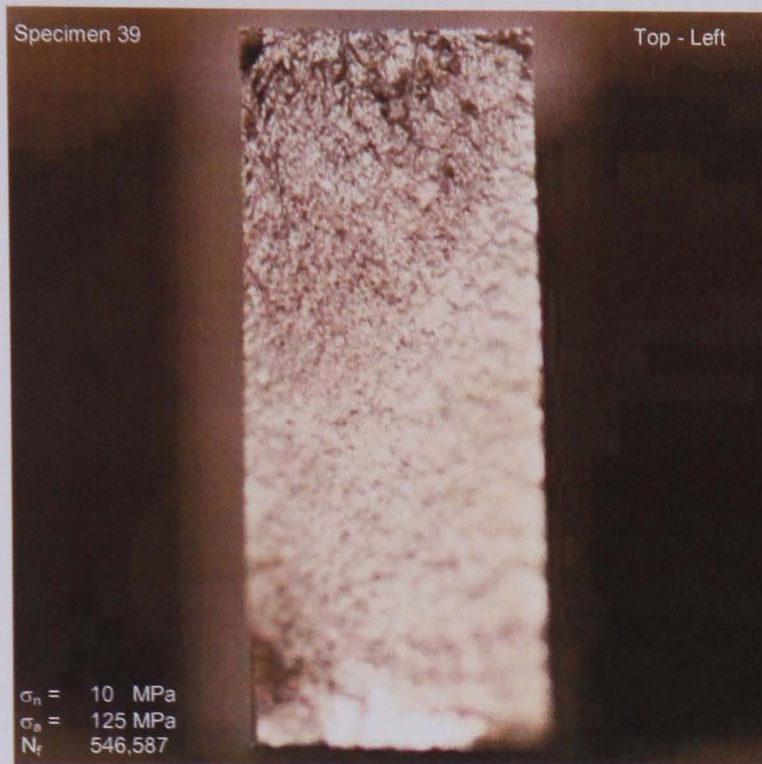


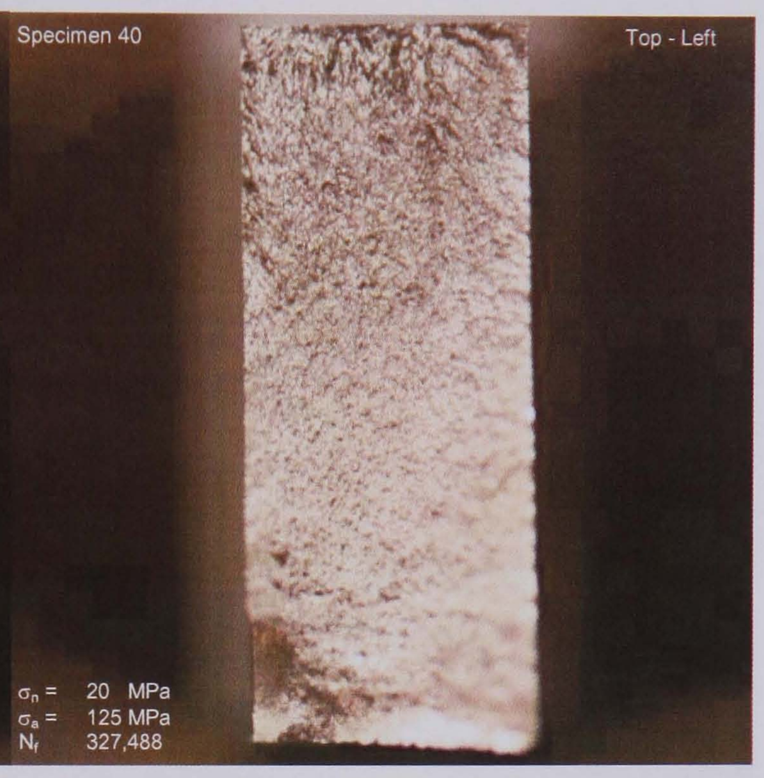
Specimen 19
Top - Right
σn = 100 MPa
σa = 100 MPa
Nf 553,971

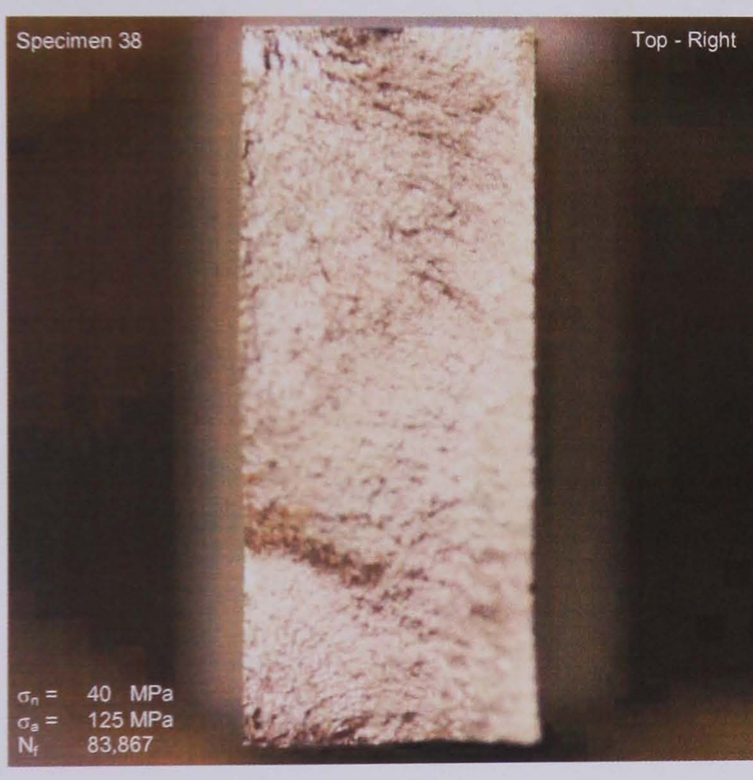


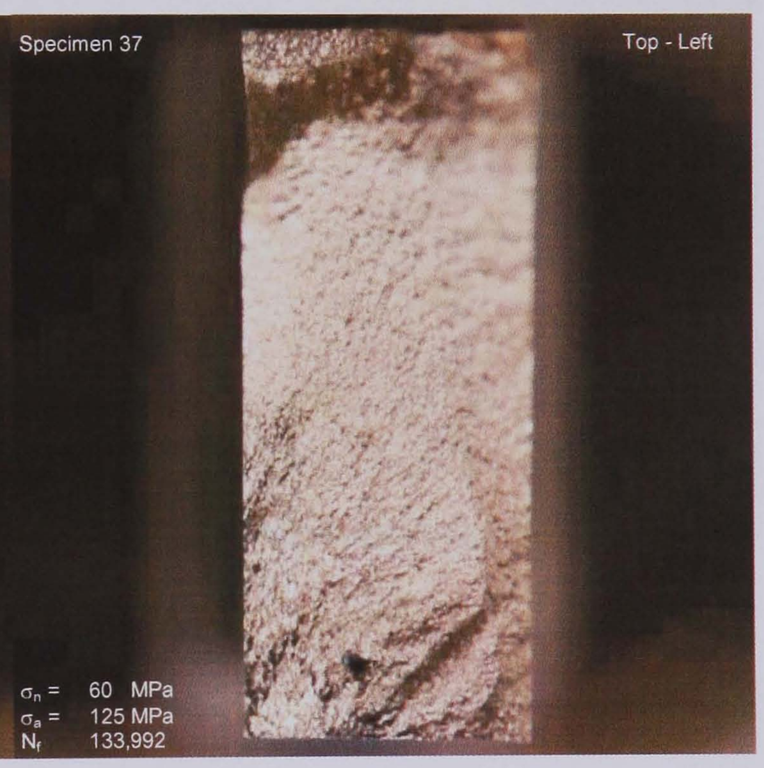
Specimen 20
Top - Right
σn = 100 MPa
σa = 100 MPa
Nf 404,431

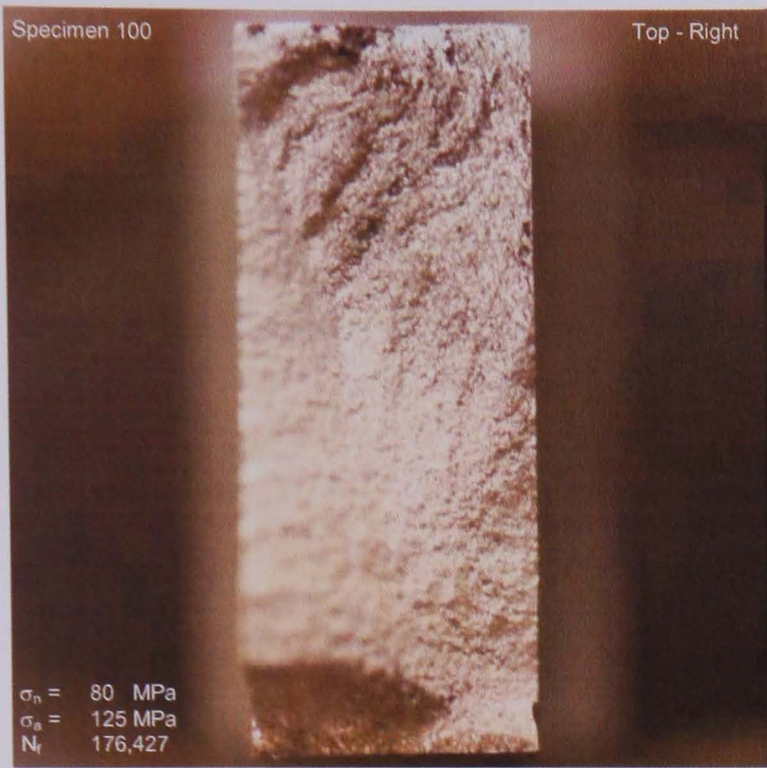
O.3 σ_a = 125 MPa unpeened

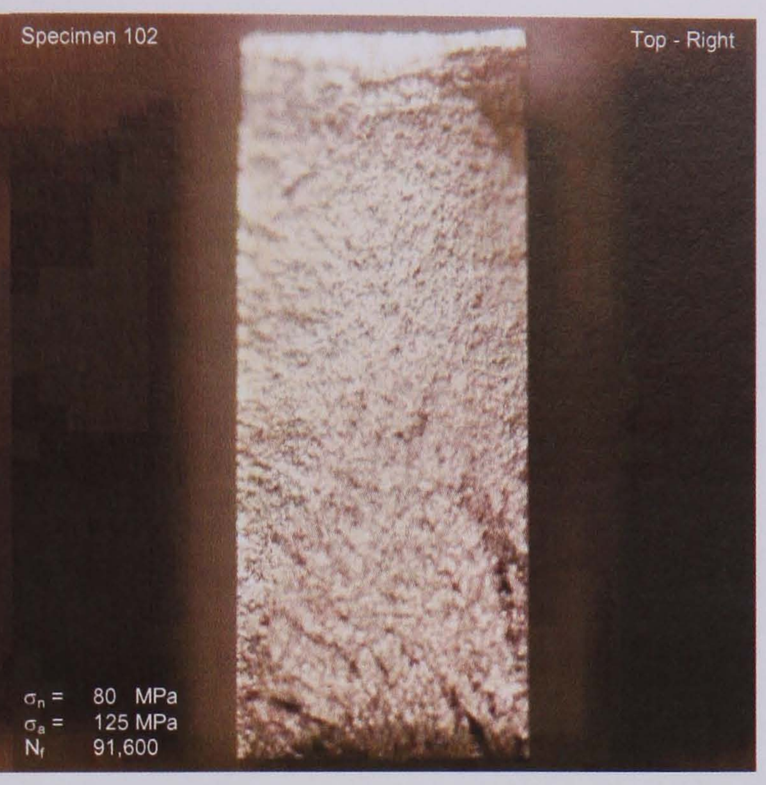


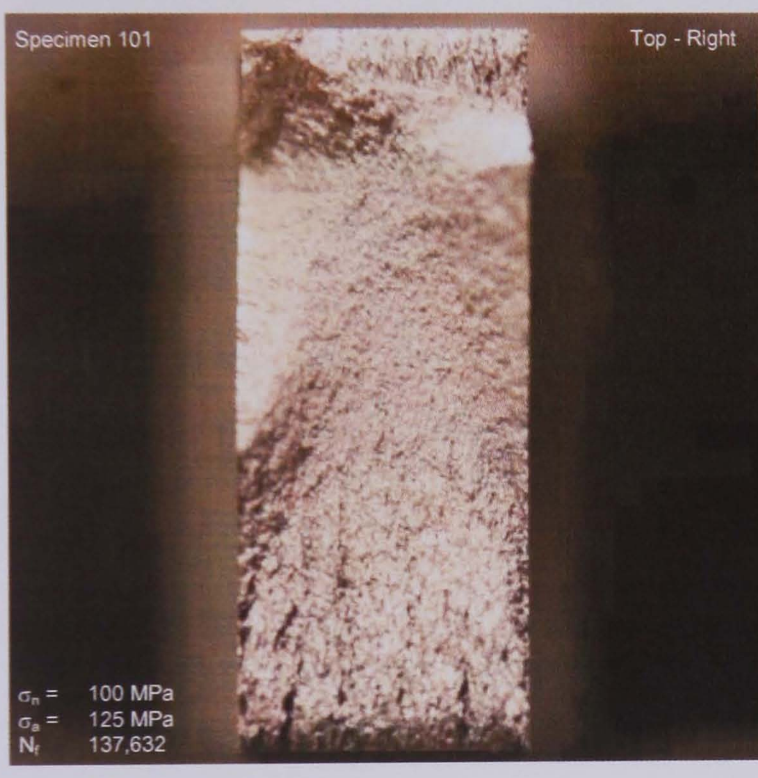


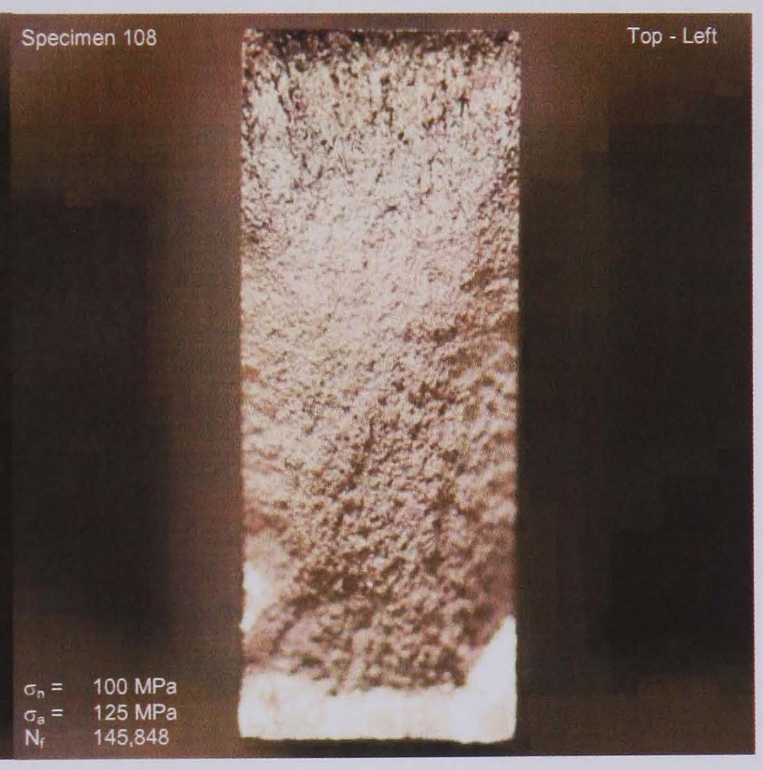




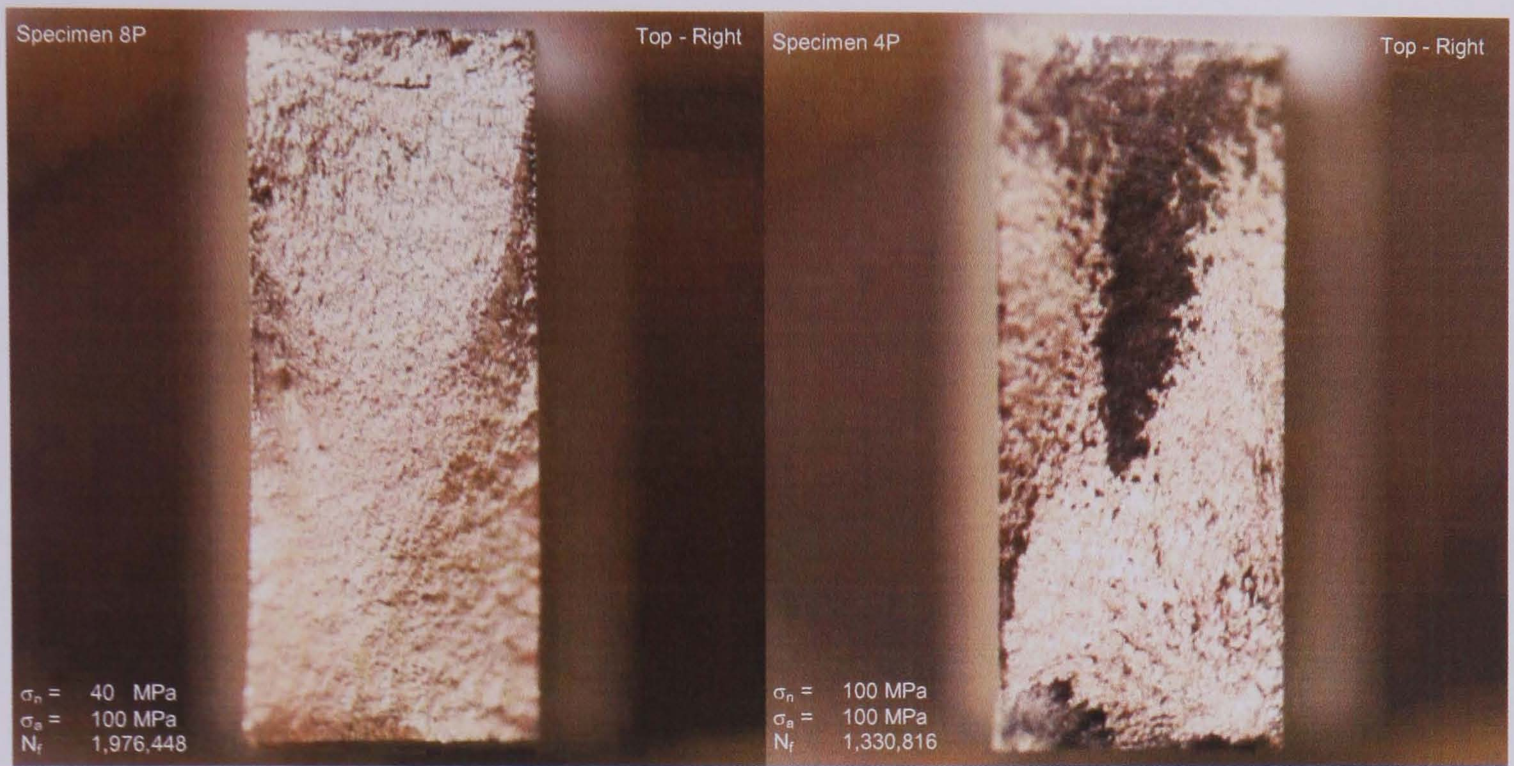

Specimen 100
Top - Right
σ_n = 80 MPa
σ_a = 125 MPa
N_f 176,427


Specimen 102
Top - Right
σ_n = 80 MPa
σ_a = 125 MPa
N_f 91,600

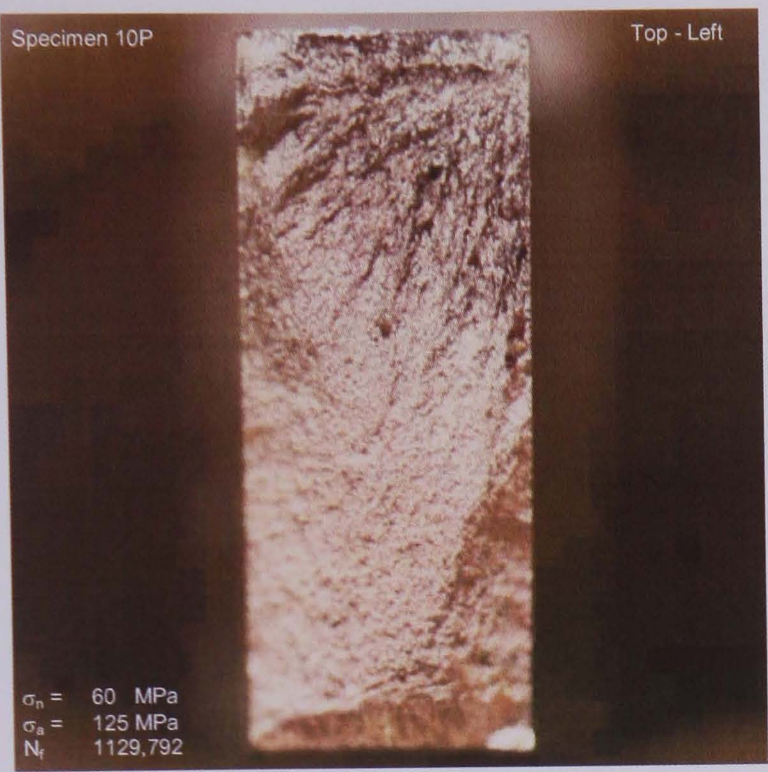

Specimen 101
Top - Right
σ_n = 100 MPa
σ_a = 125 MPa
N_f 137,632


Specimen 108
Top - Left
σ_n = 100 MPa
σ_a = 125 MPa
N_f 145,848

O.4 σ_a = 100 MPa peened



O.5 σ_a = 125 MPa peened

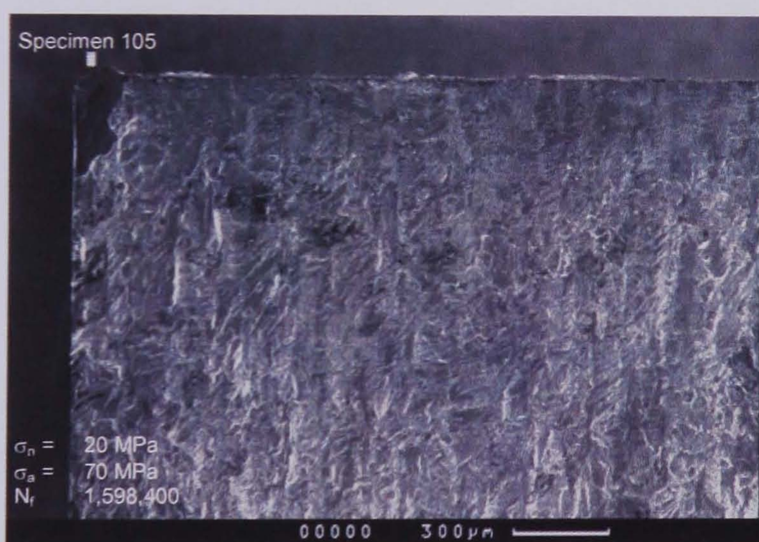


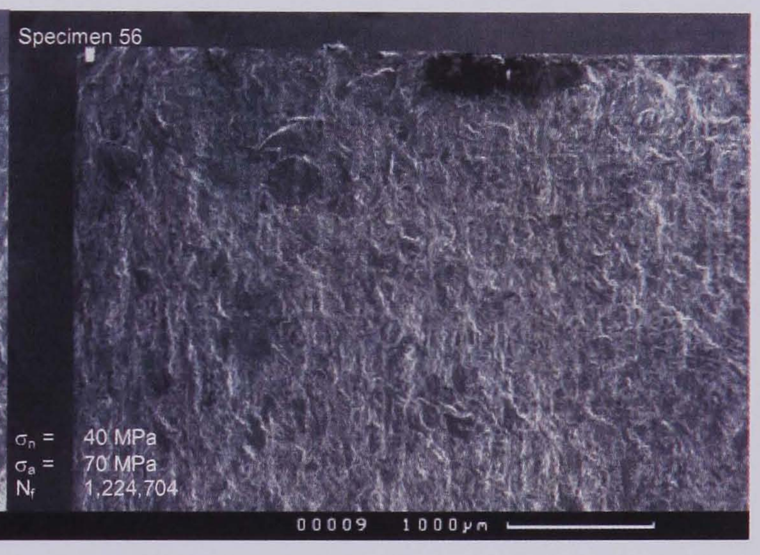
APPENDIX P

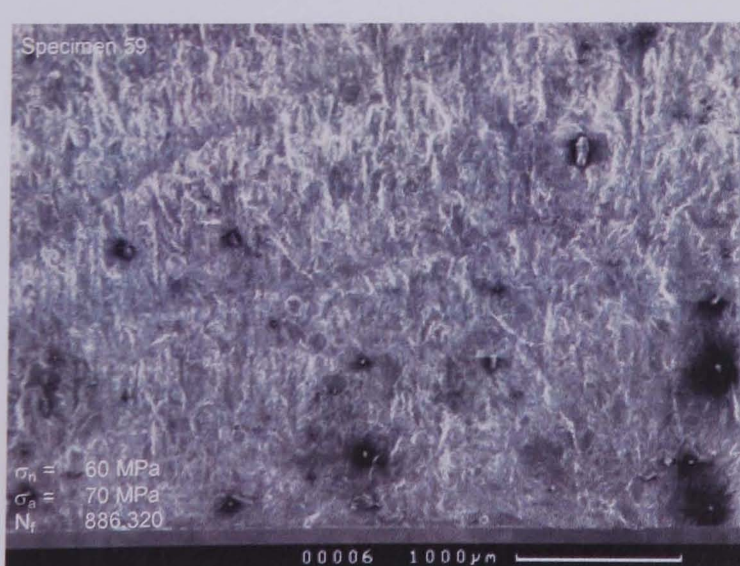
RESULTS: SEM IMAGES FRACTURE SURFACES

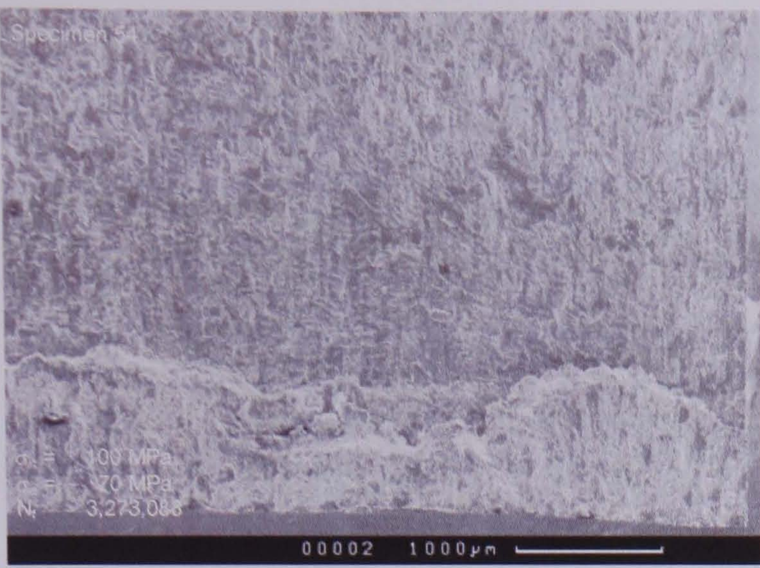
This appendix contains images of the unpeened fractured specimens taken under a scanning electron microscope. Each image shows the main crack initiation sites and displays its own scale marker.

P.1 σ_a = 70 MPa unpeened

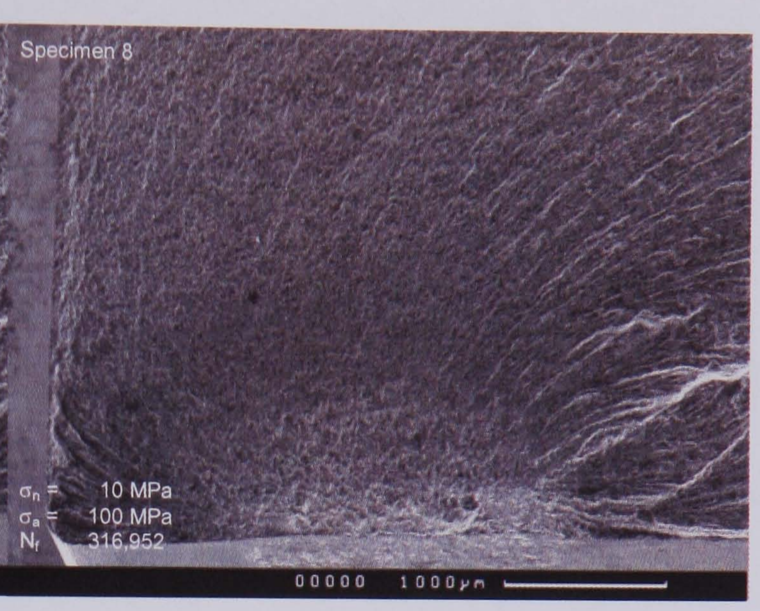


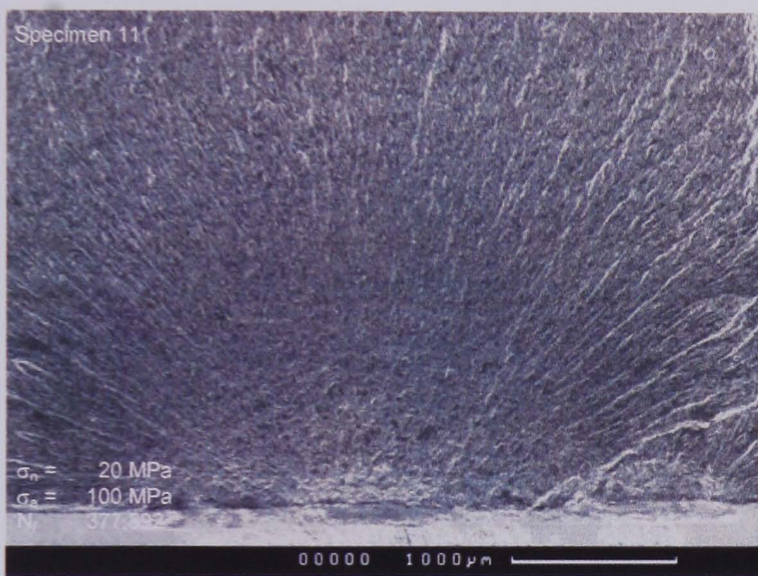


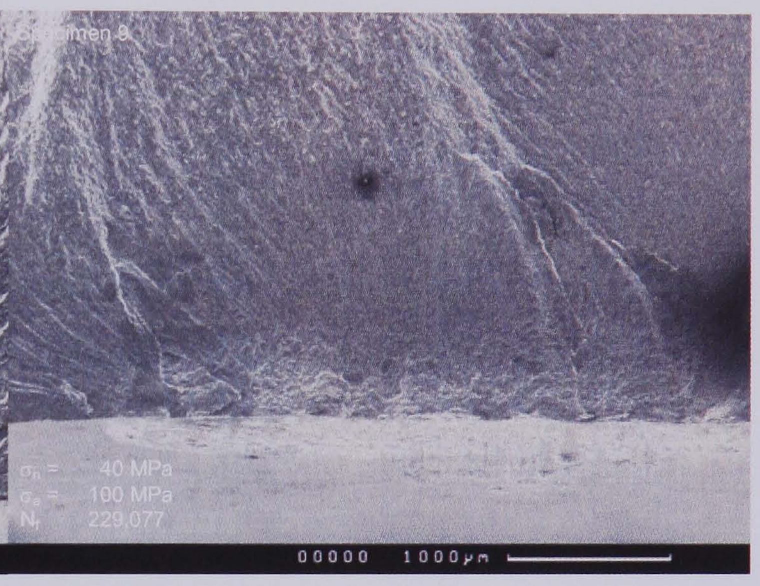


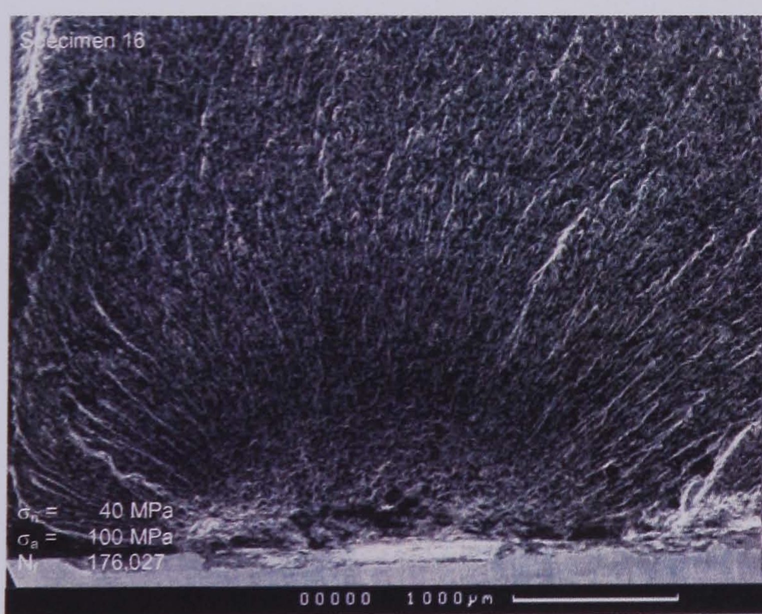

Specimen 54
100 MPa
70 MPa
00002 1000μm

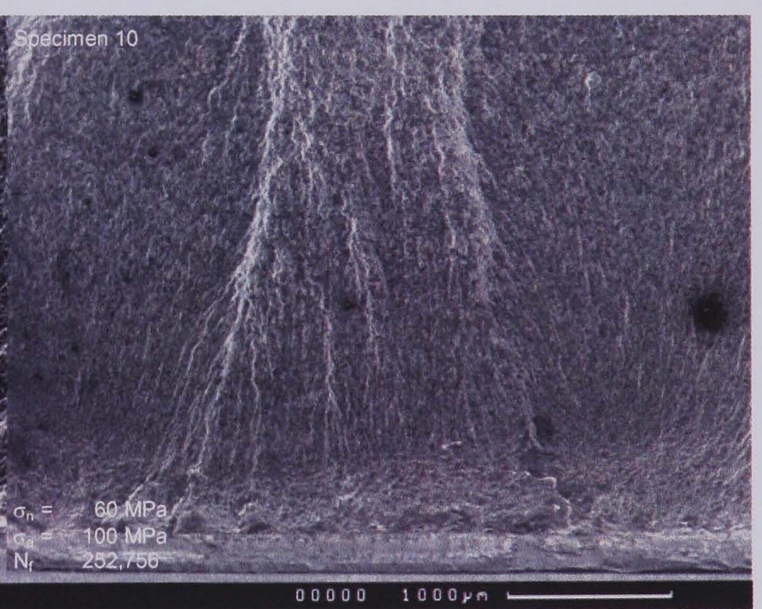
P.2 σ_a = 100 MPa unpeened





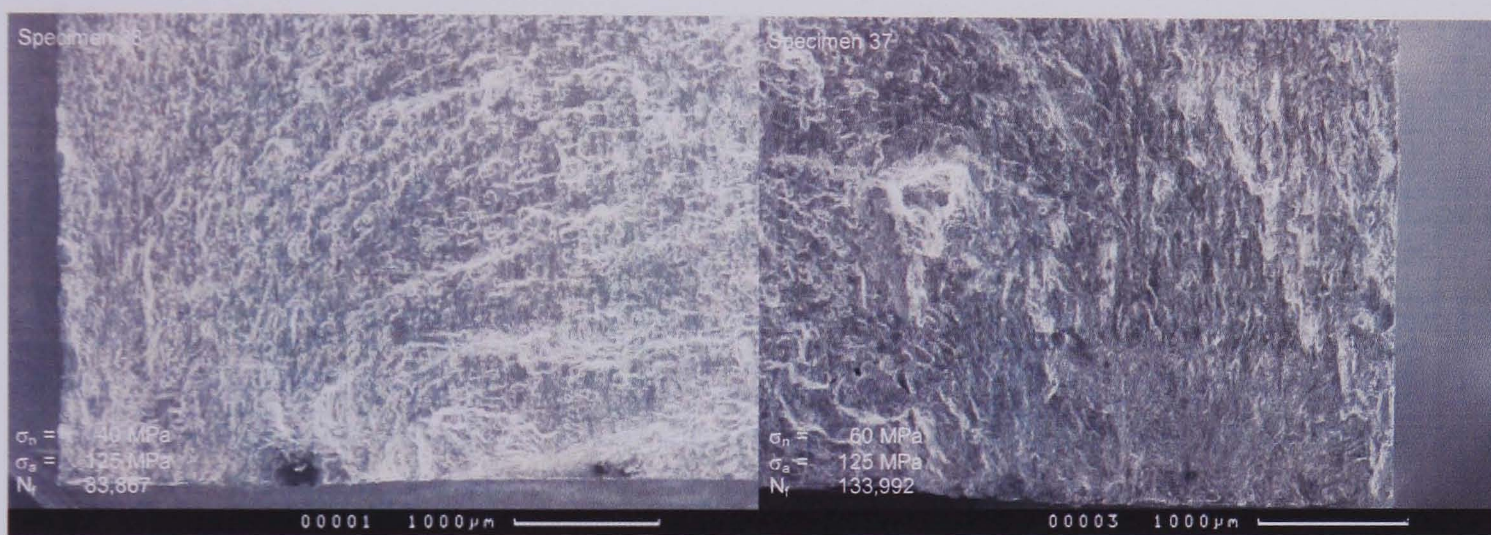


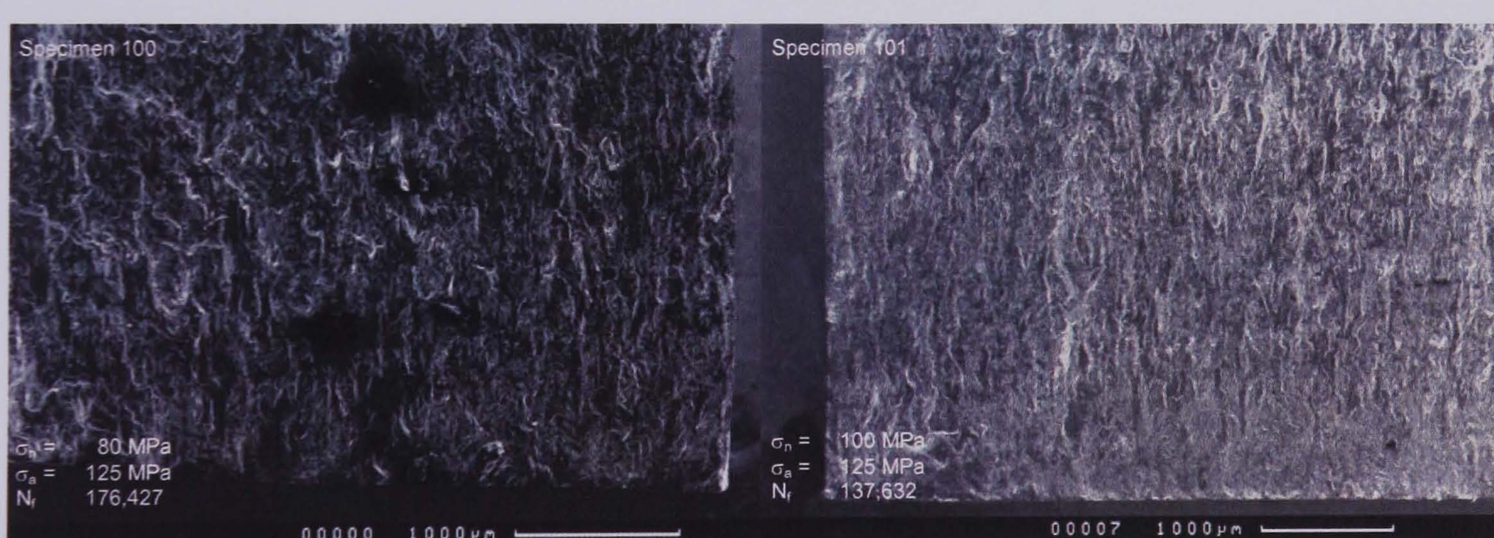





80 MPa
σ_a = 100 MPa
N_f 364,468
00000 1000μm
Specimen 20
σ_n = 100 MPa
σ_a = 100 MPa
N_f 404,431
00003 1000μm

P.3 σ_a = 125 MPa unpeened



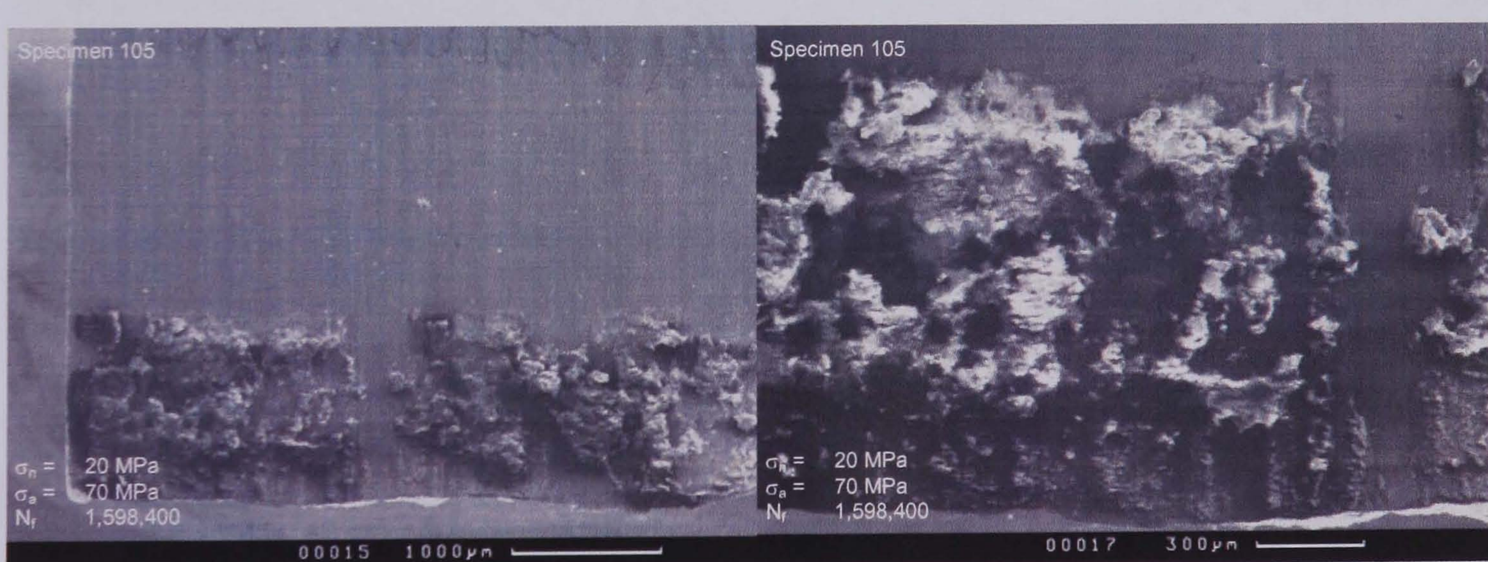


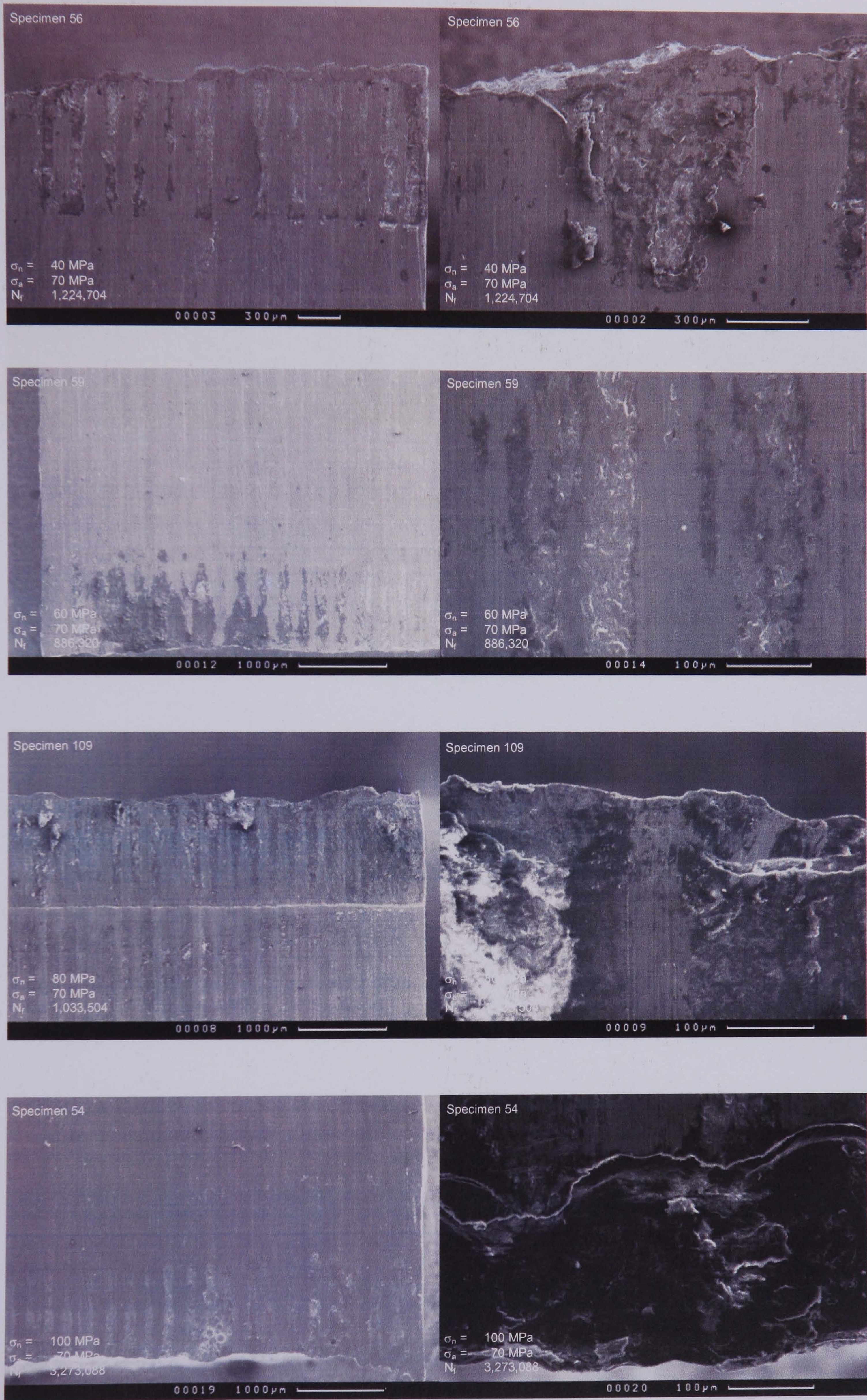
APPENDIX Q

RESULTS: SEM IMAGES
SURFACE DEGRADATION

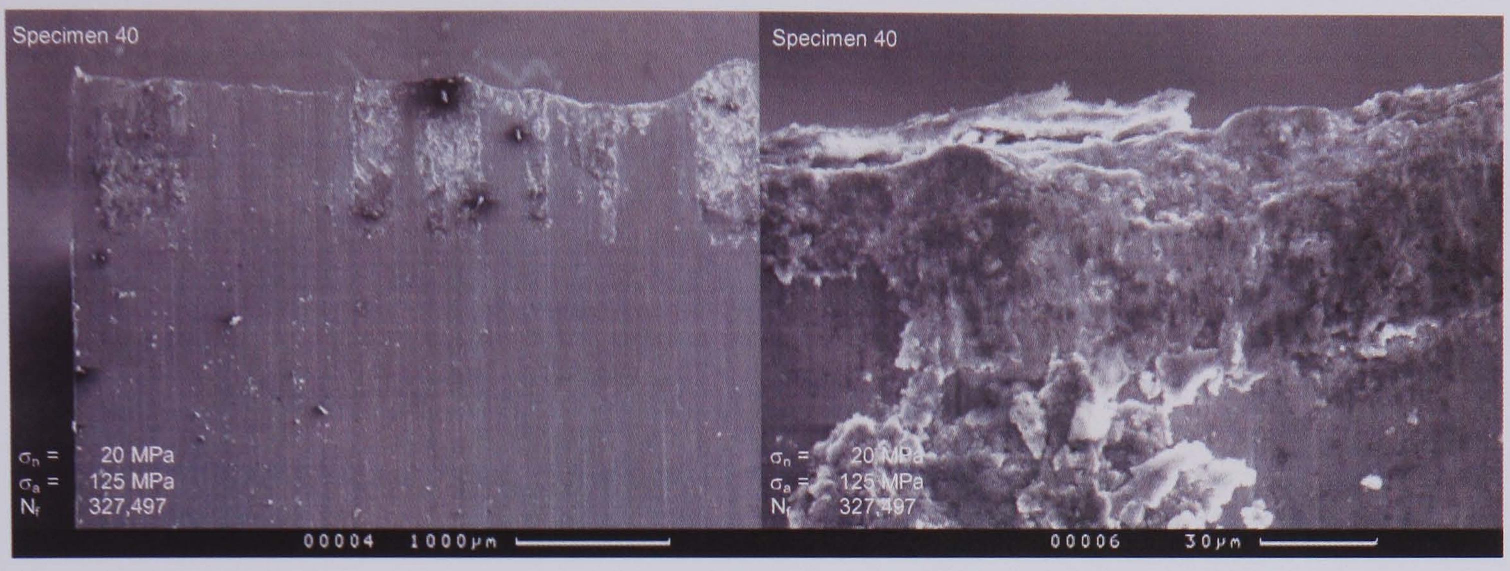
This appendix contains images of the unpeened fractured specimens taken under a scanning electron microscope. Each image depicts a wear scar and shows evidence of surface degradation; the presence of oxide debris, metal adhesion and smearing. Crack initiation occurred at the edge of these wear scars. Each image displays its own scale marker.

Q.1 σ_a = 70 MPa unpeened




Specimen 56
σ_n = 40 MPa
σ_a = 70 MPa
N_f 1,224,704
00003 300μm
Specimen 56
σ_n = 40 MPa
σ_a = 70 MPa
N_f 1,224,704
00002 300μm
Specimen 59
σ_n = 60 MPa
σ_a = 70 MPa
N_f 886,320
00012 1000μm
Specimen 59
σ_n = 60 MPa
σ_a = 70 MPa
N_f 886,320
00014 100μm
Specimen 109
σ_n = 80 MPa
σ_a = 70 MPa
N_f 1,033,504
00008 1000μm
Specimen 109
00009 100μm
Specimen 54
σ_n = 100 MPa
N_f 3,273,088
00019 1000μm
Specimen 54
σ_n = 100 MPa
σ_a = 70 MPa
N_f 3,273,088
00020 100μm

Q.2 σ_a = 125 MPa unpeened

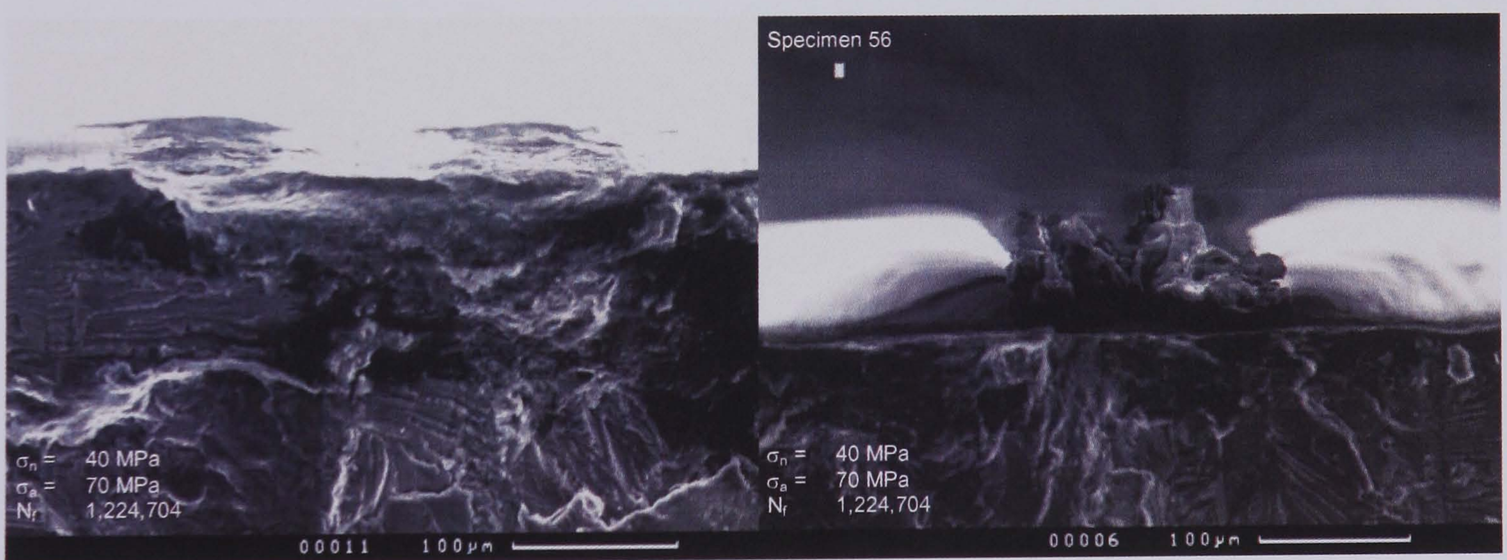


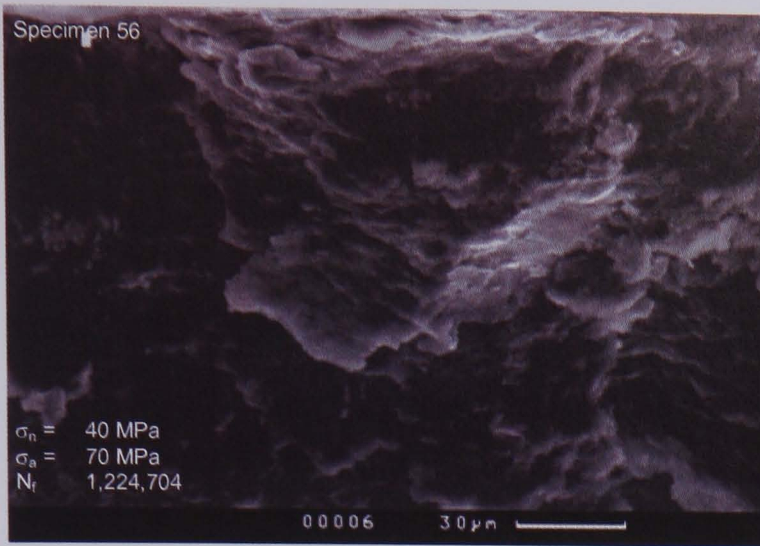
APPENDIX R

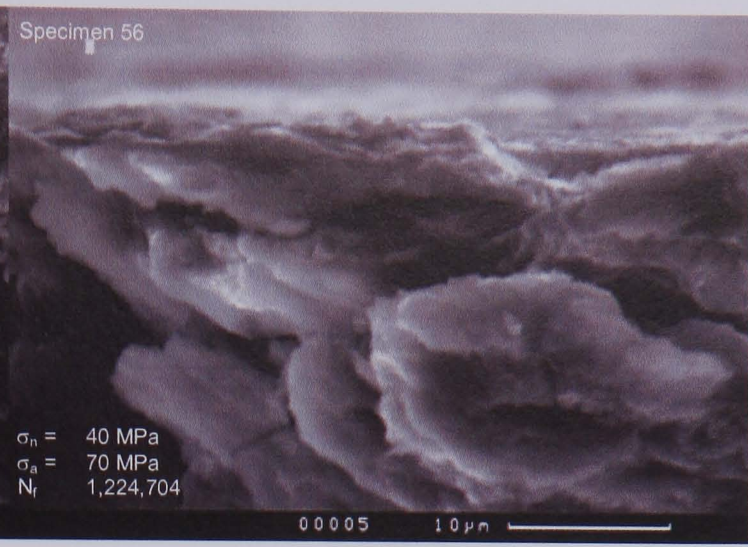
RESULTS: SEM IMAGES DEGRADATION

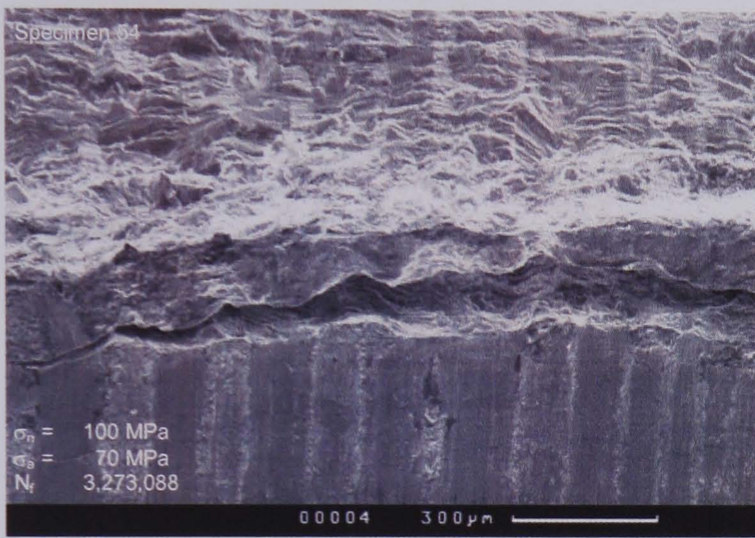
This appendix contains images of the unpeened fractured specimens taken under a scanning electron microscope. Each image depicts sub-surface degradation beneath a wear scar. Regions of rubbing near to the wear scars obliterated the primary features of the crack initiation sites. Each image displays its own scale marker.

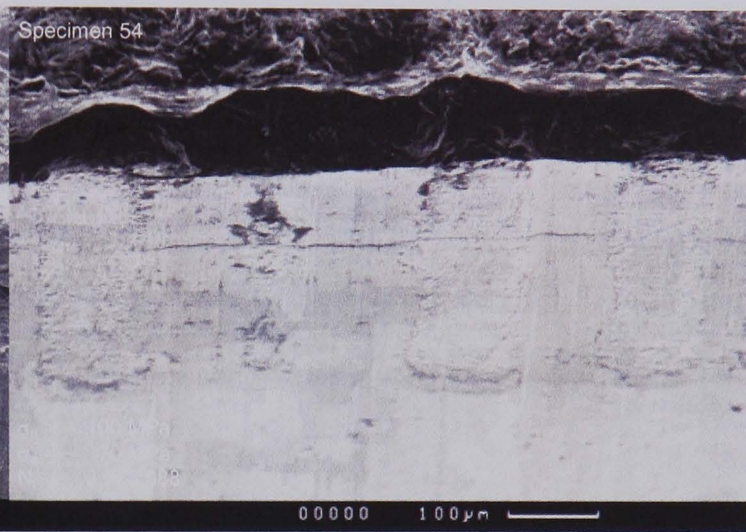
R.1 σ_a = 70 MPa unpeened

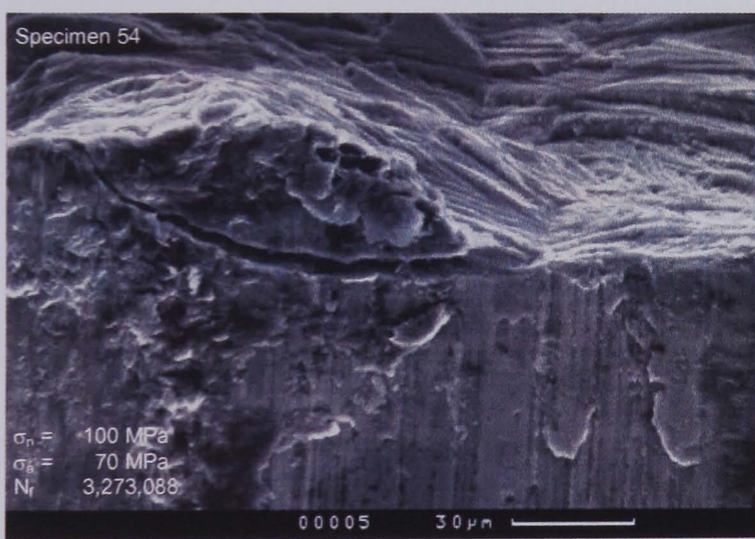


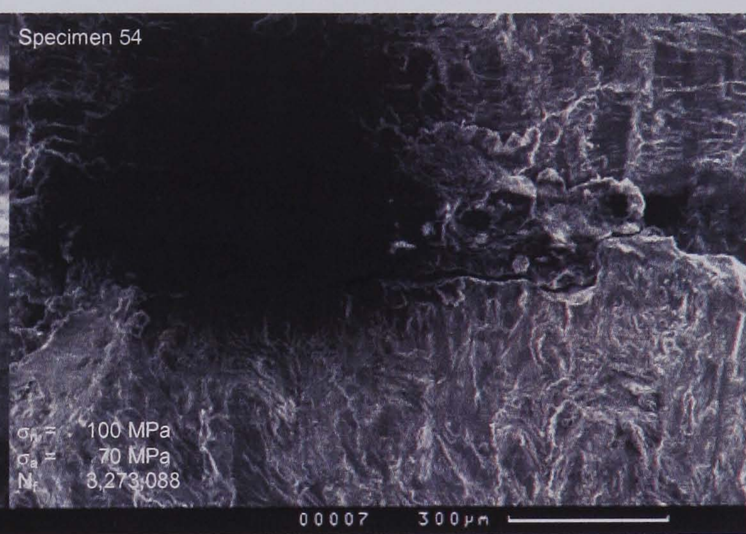

Specimen 56
σ_n = 40 MPa
σ_a = 70 MPa
N_f 1,224,704
00006 30μm


Specimen 56
σ_n = 40 MPa
σ_a = 70 MPa
N_f 1,224,704
00005 10μm

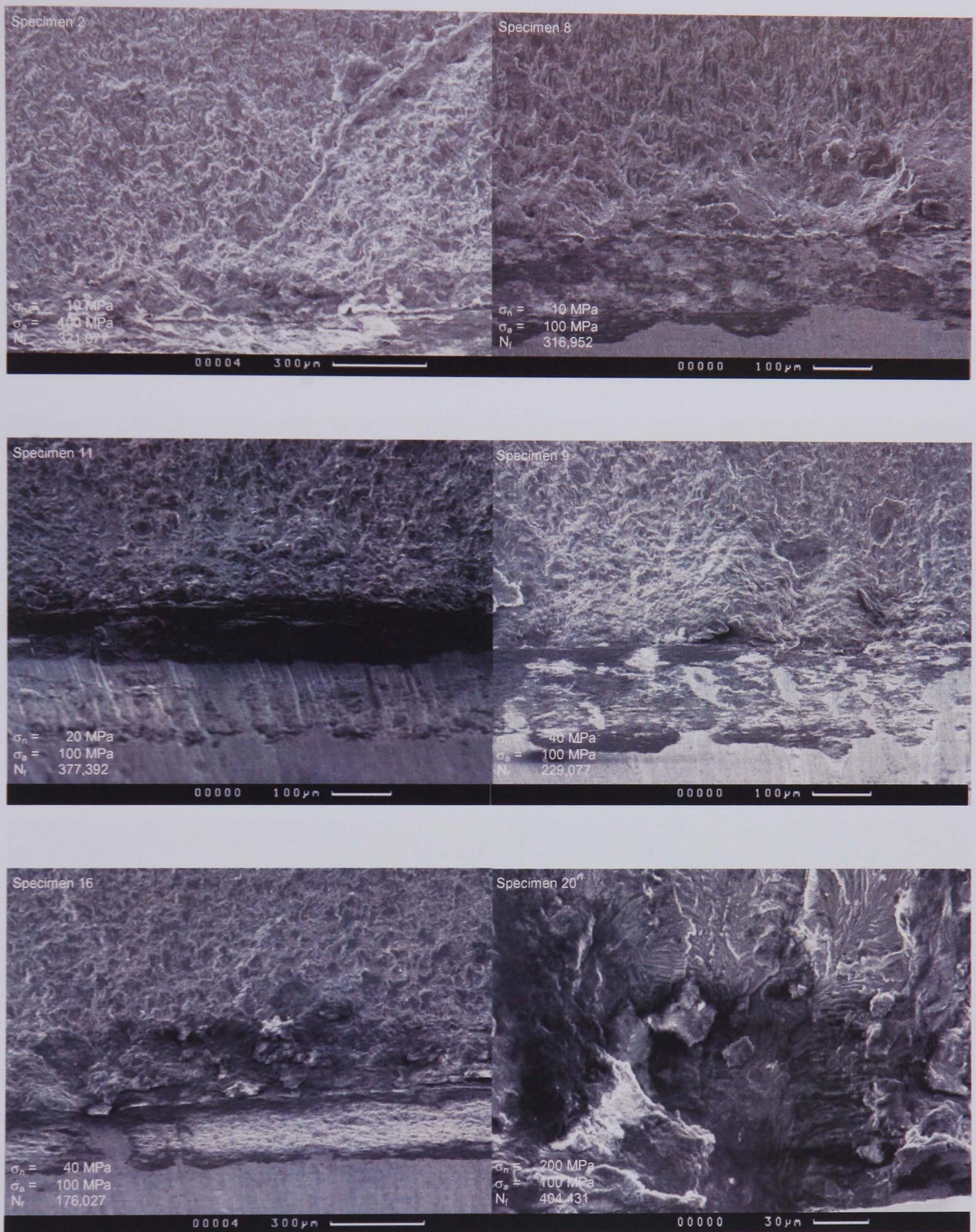

Specimen 54
σ_n = 100 MPa
σ_a = 70 MPa
N_f 3,273,088
00004 300μm


Specimen 54
00000 100μm

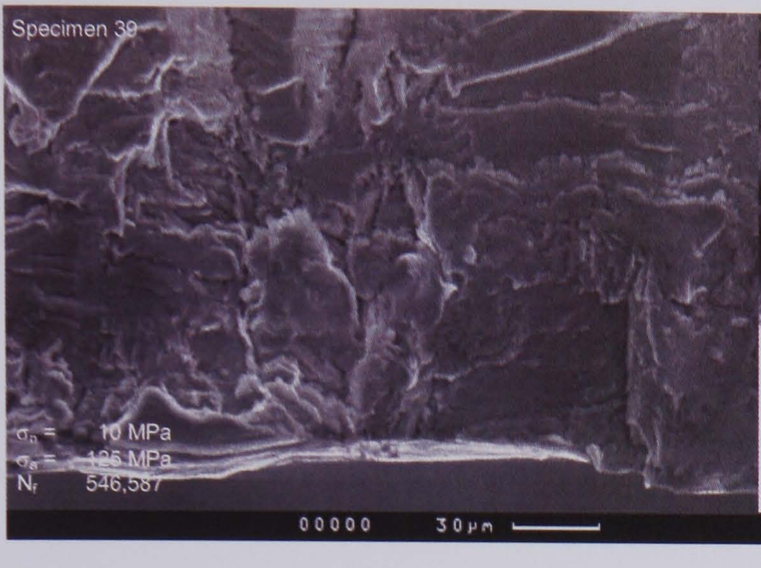

Specimen 54
σ_n = 100 MPa
σ_a = 70 MPa
N_f 3,273,088
00005 30μm

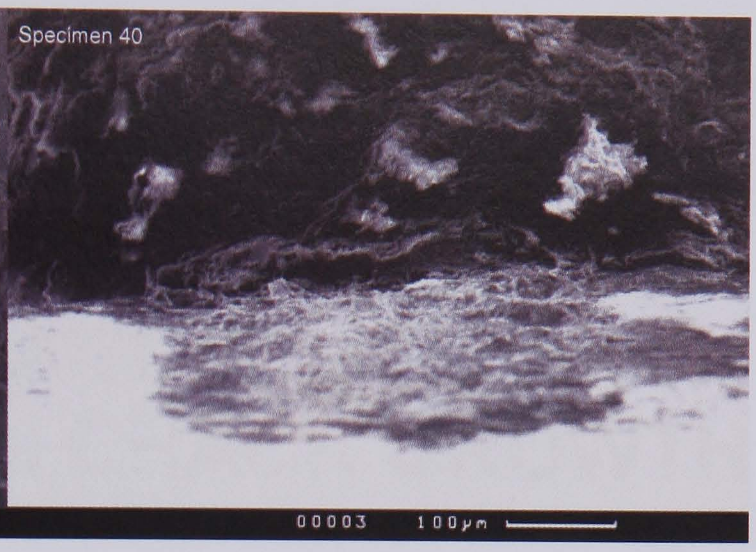

Specimen 54
σ_n = 100 MPa
σ_a = 70 MPa
N_f 3,273,088
00007 300μm

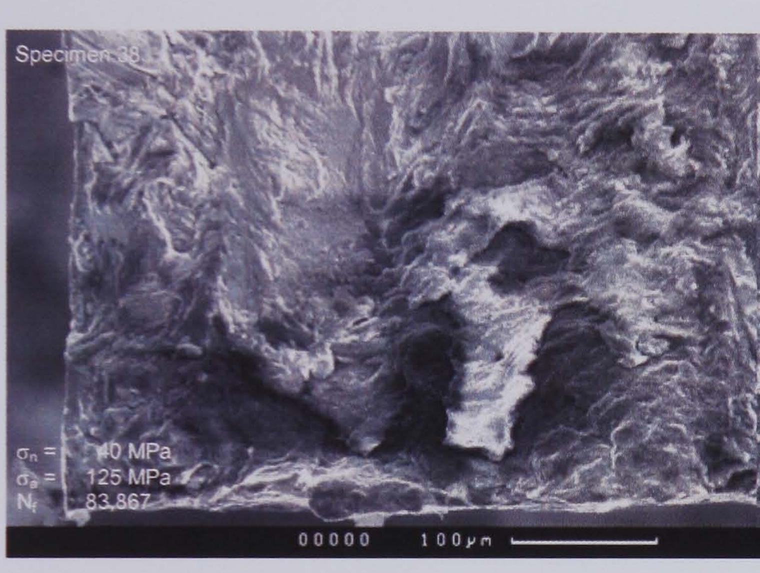
R.2 σ_a = 100 MPa unpeened

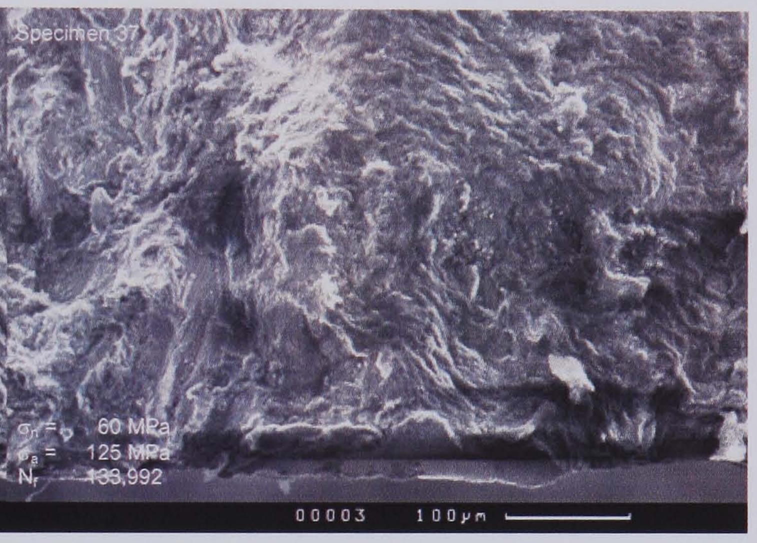


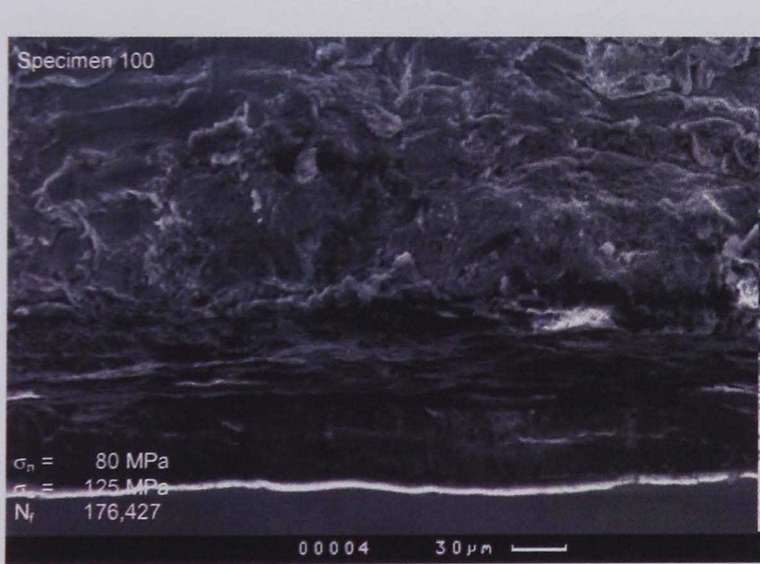
R.3 σ_a = 125 MPa unpeened

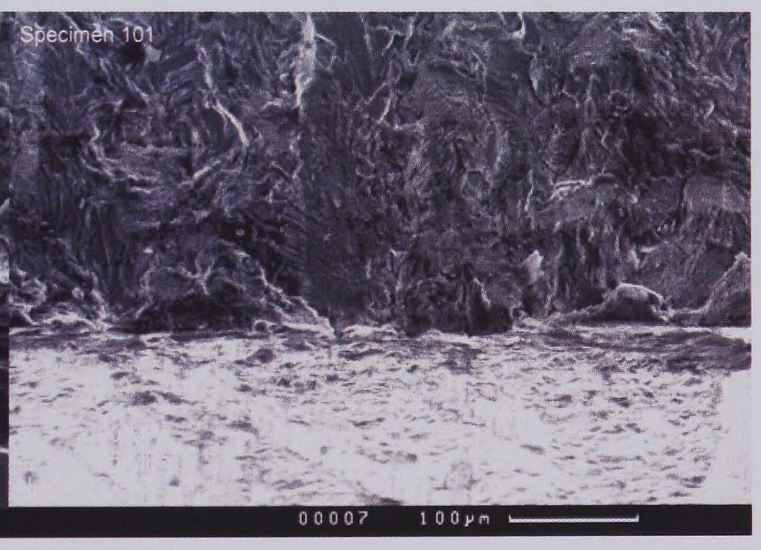










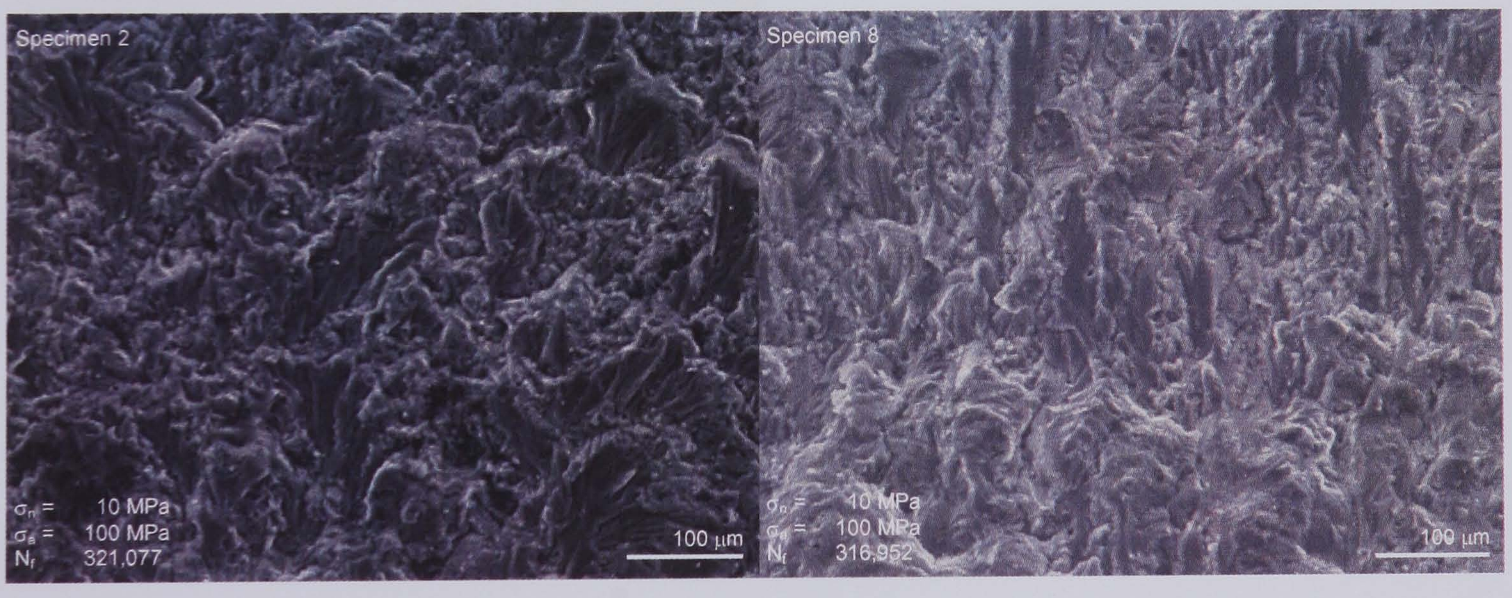


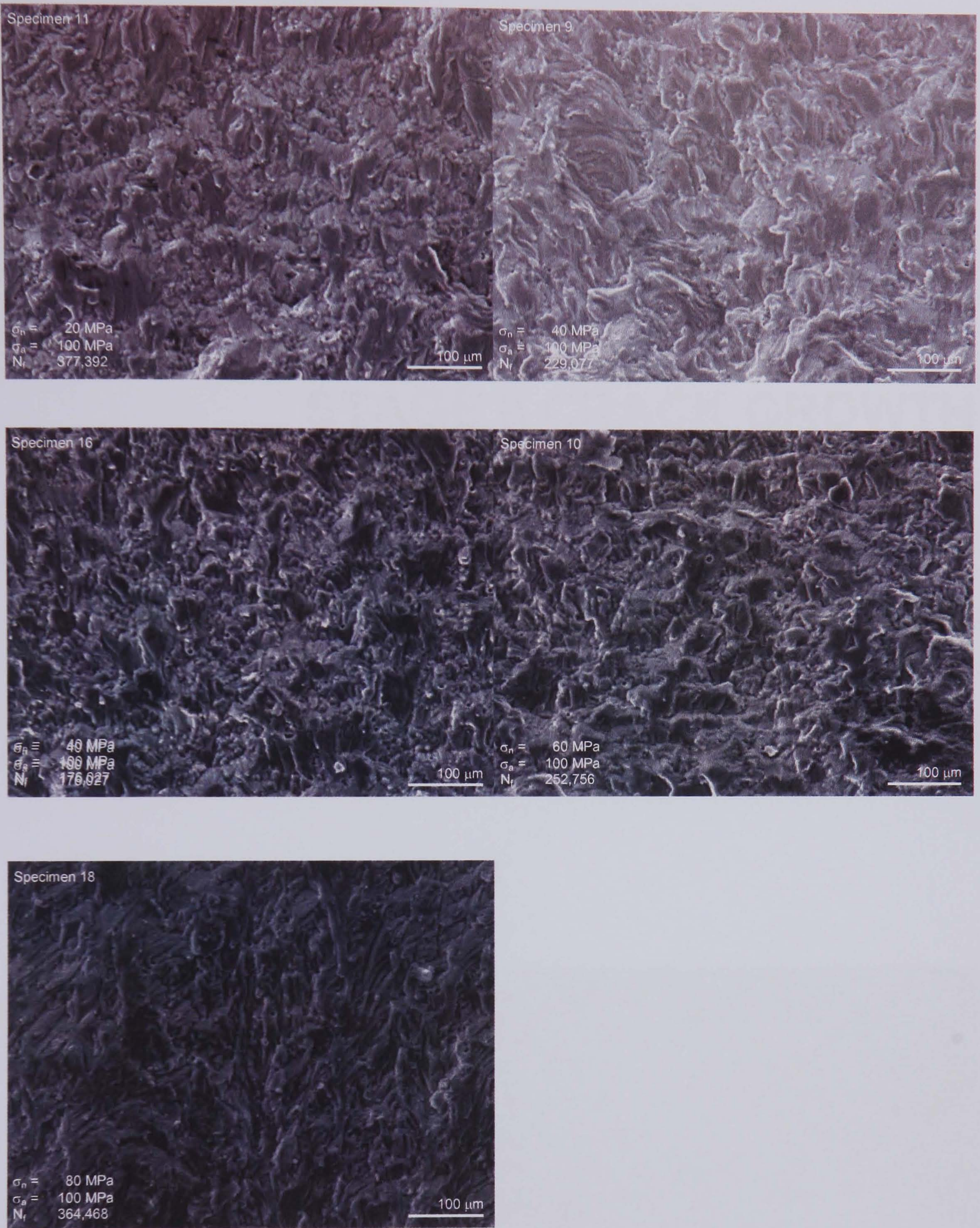
APPENDIX S

RESULTS: SEM IMAGES
STAGE I CRACK GROWTH

This appendix contains images of the unpeened fractured specimens taken under a scanning electron microscope. Each image depicts a region of crack growth in Stage I, captured at approximately 100 μm from a fretting scar, see Sections 4.4.2 and 4.5.1. Each image displays its own scale marker.

S.1 σ_a = 100 MPa unpeened





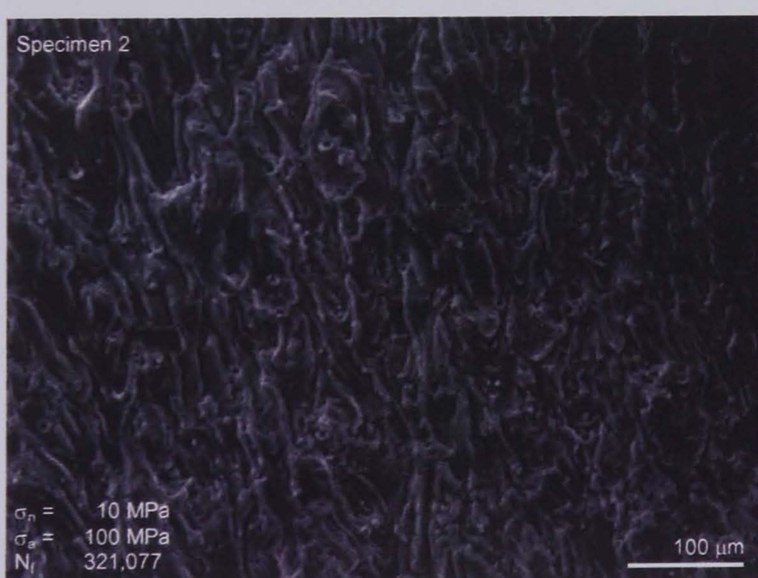
Specimen 11
σ_n = 20 MPa
σ_a = 100 MPa
N_f 377,392
100 μm
Specimen 9
σ_n = 40 MPa
σ_a = 100 MPa
N_f 229,077
100 μm
Specimen 16
σ_n = 40 MPa
σ_a = 100 MPa
N_f 176,027
100 μm
Specimen 10
σ_n = 60 MPa
σ_a = 100 MPa
N_f 252,756
100 μm
Specimen 18
σ_n = 80 MPa
σ_a = 100 MPa
N_f 364,468
100 μm

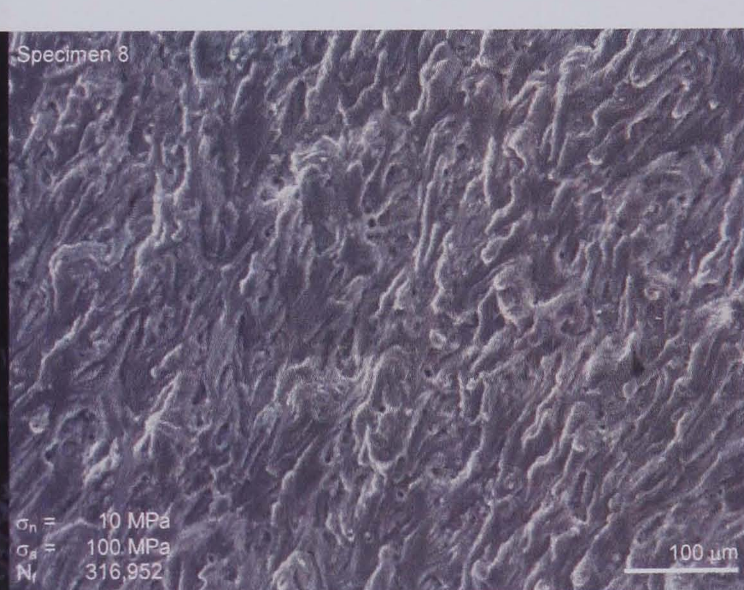
APPENDIX T

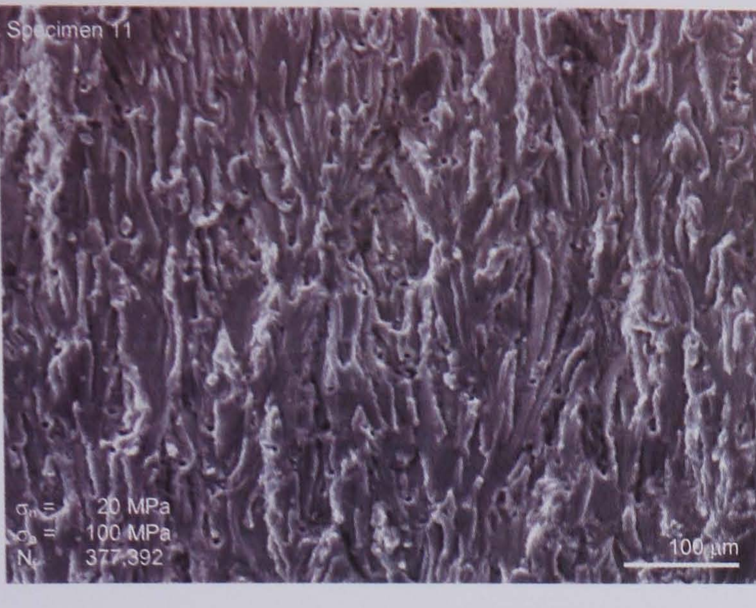
RESULTS: SEM IMAGES
STAGE II CRACK GROWTH

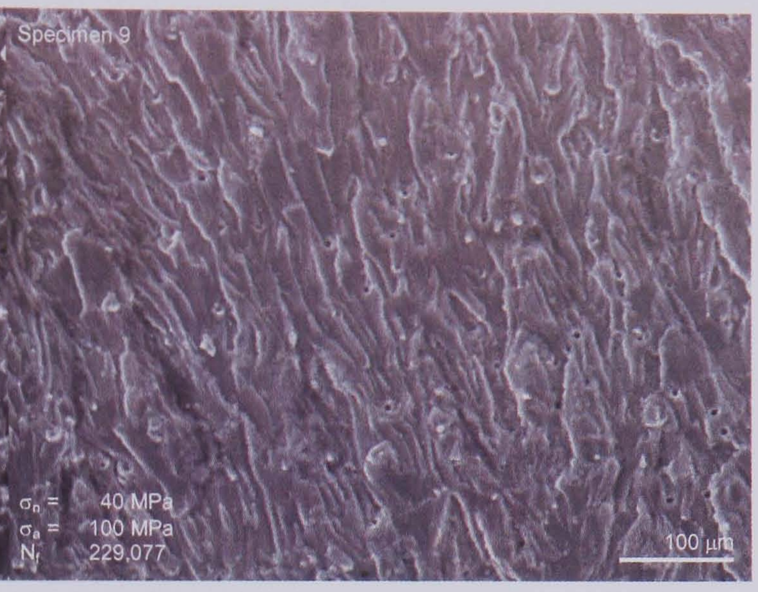
This appendix contains images of the unpeened fractured specimens taken under a scanning electron microscope. Each image depicts a region of crack growth on a transverse crack face in Stage II, captured at approximately 1 mm from a fretting scar, see Sections 4.4.2 and 4.5.1. Each image displays its own scale marker.

T.1 σ_a = 100 MPa unpeened



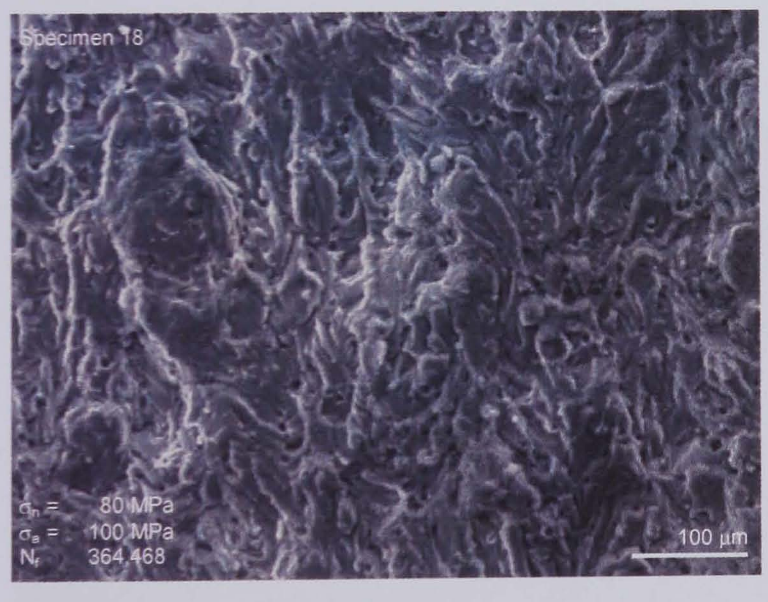



Specimen 11
σ_n = 20 MPa
σ_a = 100 MPa
N_f 377,392
100 μm


Specimen 9
σ_n = 40 MPa
σ_a = 100 MPa
N_f 229,077
100 μm


Specimen
σ_n = 40 MPa
σ_a = 100 MPa
N_f 176,027
100 μm


Specimen 10
σ_n = 60 MPa
σ_a = 100 MPa
N_f 252,756
100 μm

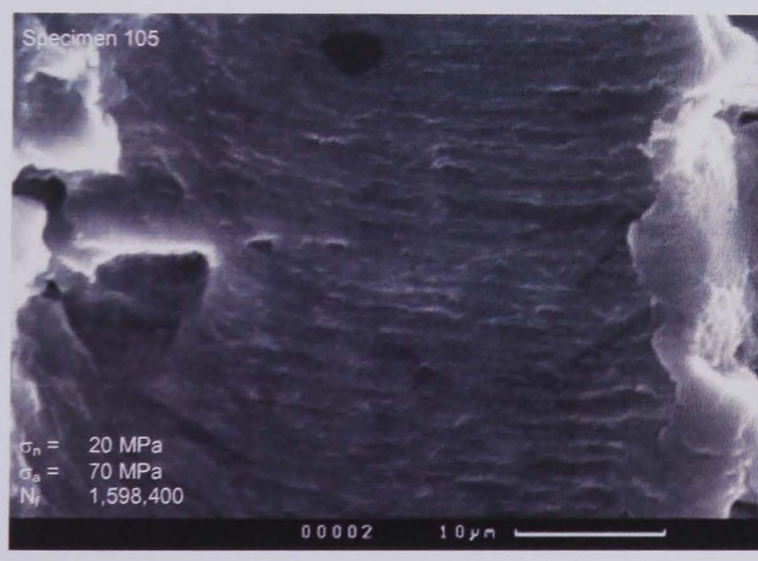

Specimen 18
σ_n = 80 MPa
σ_a = 100 MPa
N_f 364,468
100 μm

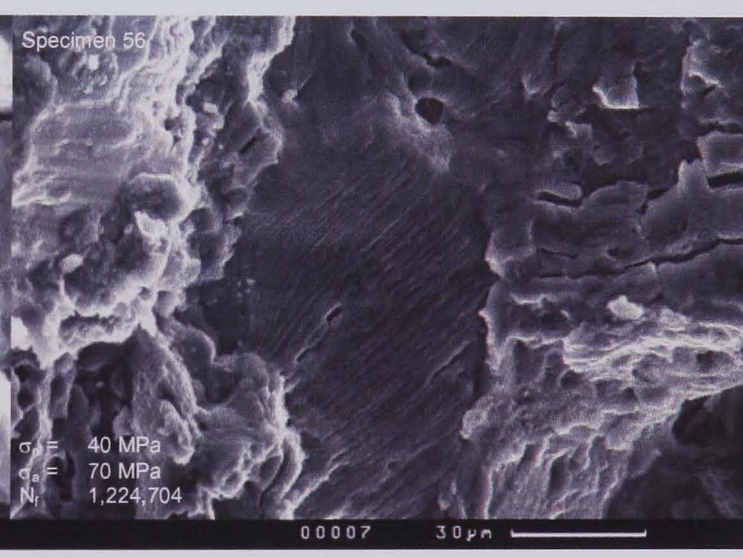
APPENDIX U

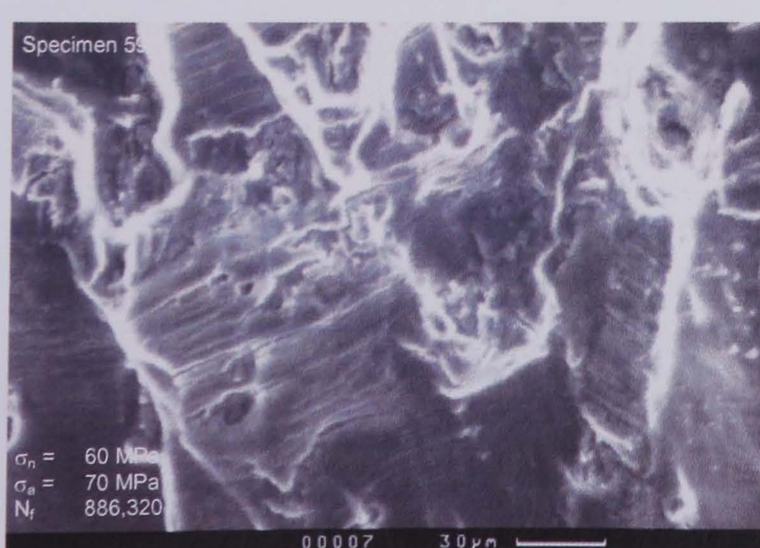
RESULTS: SEM IMAGES STRIATIONS

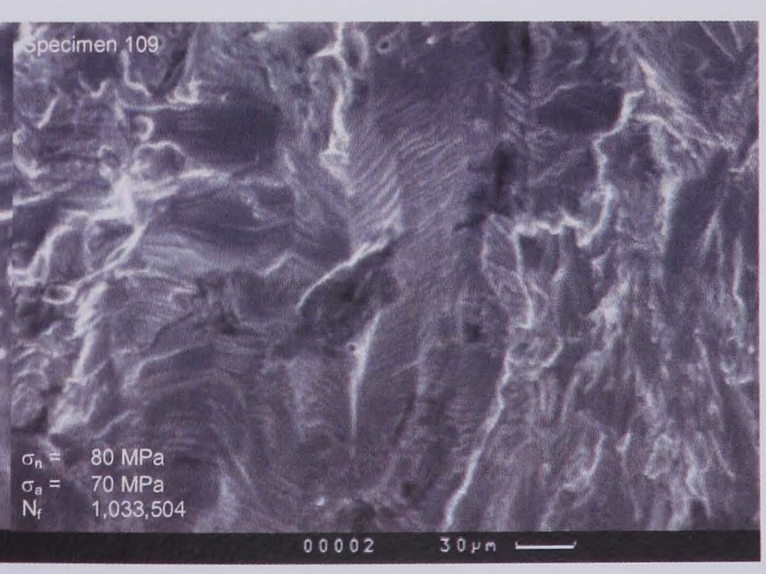
This appendix contains images of the unpeened fractured specimens taken under a scanning electron microscope. Each image depicts striation markings captured in a region of Stage II crack growth, see Sections 4.4.2 and 4.5.1. Each image displays its own scale marker.

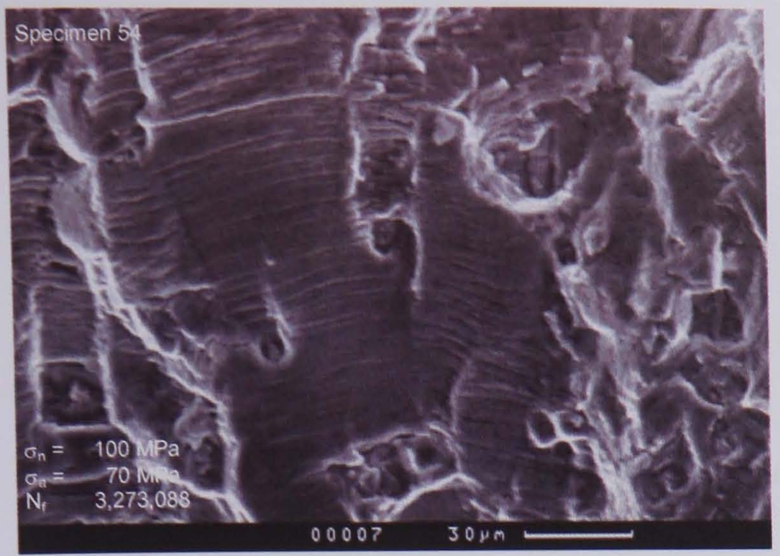
U.1 σ_a = 70 MPa unpeened



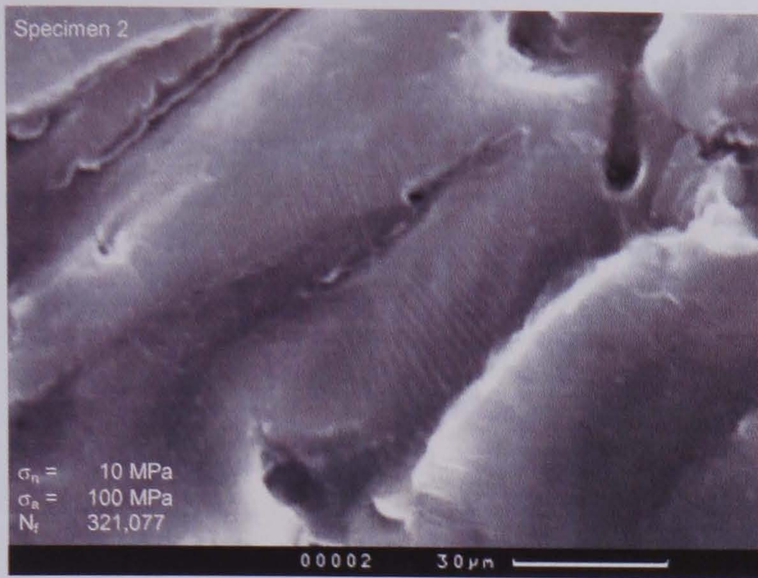


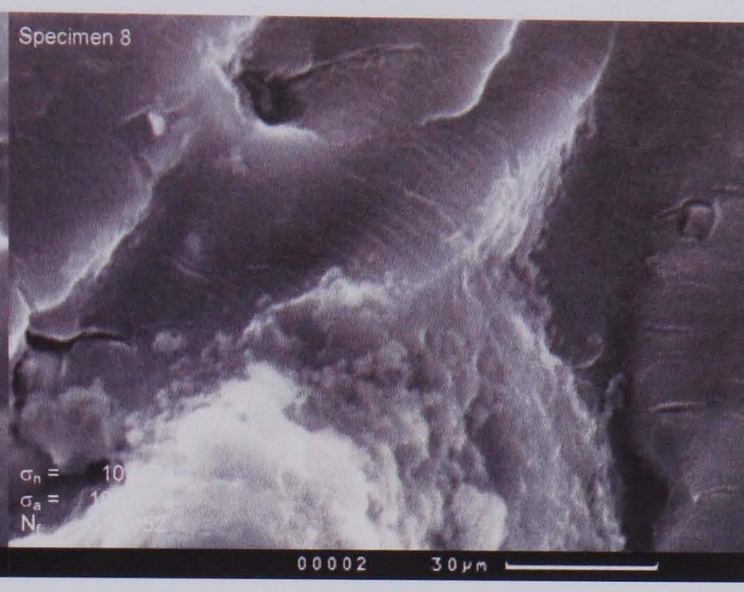


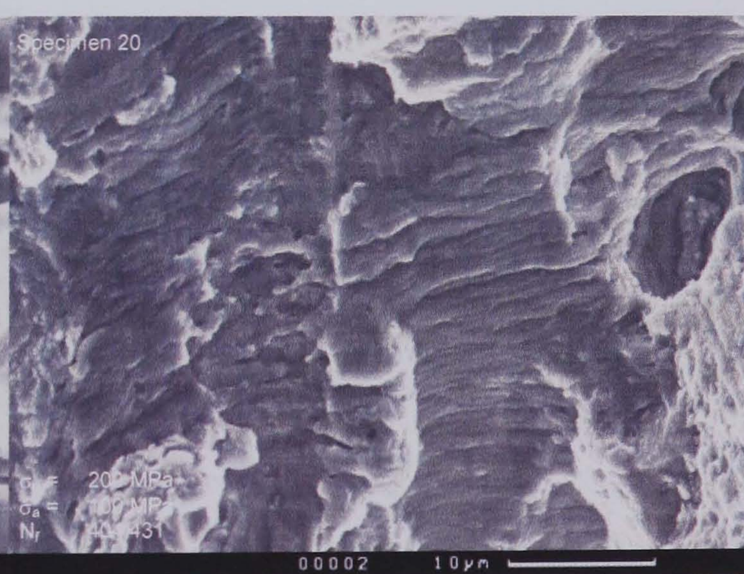



Specimen 54
σn = 100 MPa
σa = 70 MPa
Nf 3,273,088
00007 30μm

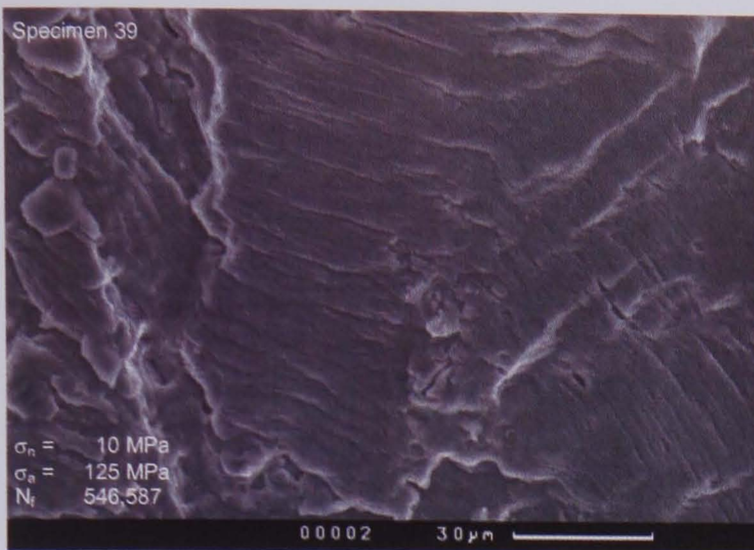
U.2 σ_a = 100 MPa unpeened

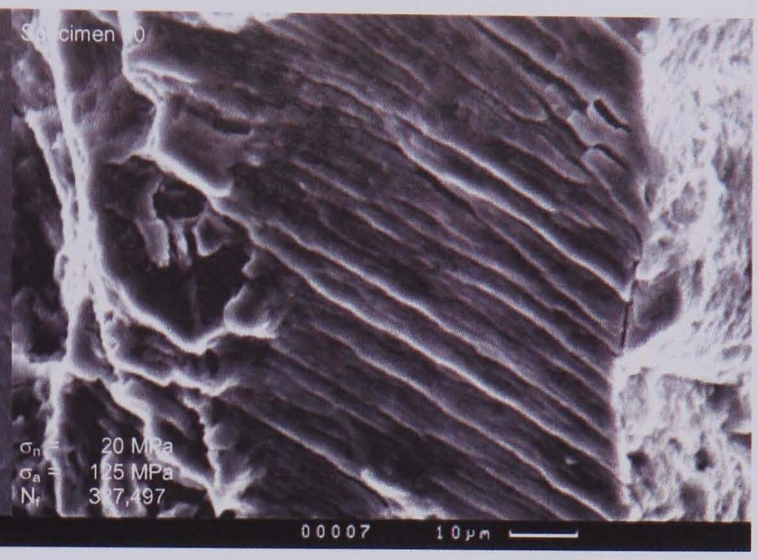


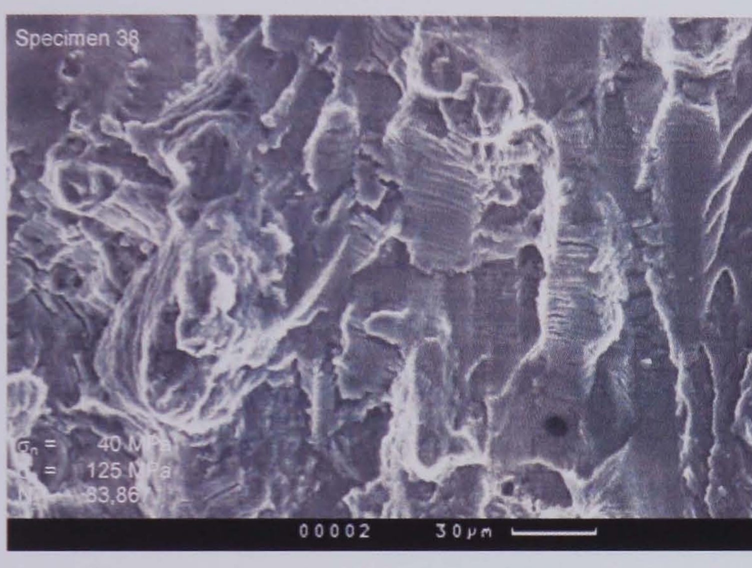


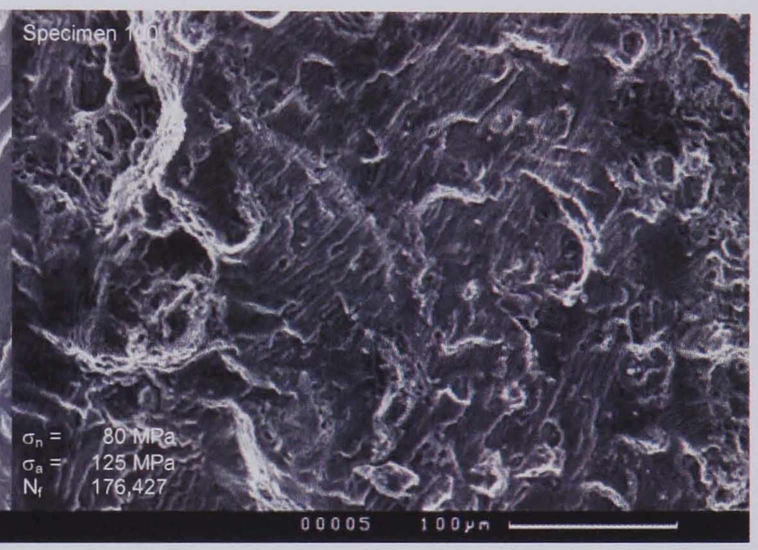


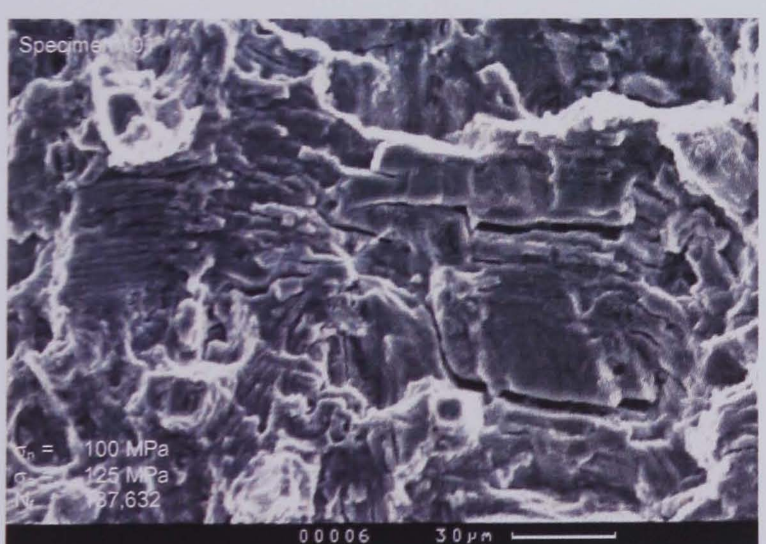
U.3 σ_a = 125 MPa unpeened











APPENDIX V

ANALYTICAL MODEL: Y_I AND Y_{II}

a (m)	$Y_{I\ axial}$	Polynomial (2nd order)	Difference (%)	Polynomial (3rd order)	Difference (%)	Polynomial (4th order)	Difference (%)	Polynomial (5th order)	Difference (%)	Polynomial (6th order)	Difference (%)	Polynomial (7th order)	Difference (%)	Polynomial (8th order)	Difference (%)	Polynomial (9th order)	Difference (%)	Polynomial (10th order)	Difference (%)
0.0001	0.296200	0.349247	0.281	0.319231	0.053	0.302256	0.004	0.299637	0.001	0.298709	0.001	0.298438	0.001	0.299263	0.001	0.299080	0.001	0.299720	0.001
0.0002	0.423142	0.433319	0.010	0.422261	0.000	0.423154	0.000	0.424670	0.000	0.424586	0.000	0.426761	0.001	0.424460	0.000	0.425145	0.000	0.422082	0.000
0.0003	0.535980	0.513972	0.048	0.516605	0.038	0.526432	0.009	0.528867	0.005	0.528815	0.005	0.529597	0.004	0.530249	0.003	0.529679	0.004	0.534022	0.000
0.0004	0.606504	0.591204	0.023	0.602882	0.001	0.615163	0.007	0.616814	0.011	0.616555	0.010	0.615869	0.009	0.617685	0.013	0.617235	0.012	0.617439	0.012
0.0005	0.691132	0.665017	0.068	0.681713	0.009	0.692110	0.000	0.692363	0.000	0.691964	0.000	0.690910	0.000	0.691611	0.000	0.691889	0.000	0.688444	0.001
0.0006	0.761656	0.735410	0.069	0.753717	0.006	0.759734	0.000	0.758692	0.001	0.758333	0.001	0.757843	0.001	0.756920	0.002	0.757486	0.002	0.755980	0.003
0.0007	0.818075	0.802383	0.025	0.819513	0.000	0.820187	0.000	0.818362	0.000	0.818214	0.000	0.818562	0.000	0.816980	0.000	0.817197	0.000	0.819394	0.000
0.0008	0.874494	0.865936	0.007	0.879720	0.003	0.875314	0.000	0.873367	0.000	0.873531	0.000	0.874378	0.000	0.873440	0.000	0.873120	0.000	0.876080	0.000
0.0009	0.930913	0.926069	0.002	0.934959	0.002	0.926655	0.002	0.925201	0.003	0.925680	0.003	0.926386	0.002	0.926761	0.002	0.926233	0.002	0.926524	0.002
0.001	0.973227	0.982782	0.009	0.985849	0.016	0.975443	0.000	0.974908	0.000	0.975624	0.001	0.975614	0.001	0.976991	0.001	0.976740	0.001	0.974120	0.000
0.0011	1.029646	1.036075	0.004	1.033009	0.001	1.022603	0.005	1.023138	0.004	1.023968	0.003	1.023016	0.004	1.024393	0.003	1.024643	0.003	1.022023	0.006
0.0012	1.071960	1.085949	0.020	1.077058	0.003	1.068755	0.001	1.070209	0.000	1.071028	0.000	1.069361	0.001	1.069736	0.000	1.070265	0.000	1.070556	0.000
0.0013	1.114274	1.132402	0.033	1.118618	0.002	1.114212	0.000	1.116159	0.000	1.116890	0.001	1.115081	0.000	1.114143	0.000	1.114463	0.000	1.117422	0.001
0.0014	1.156589	1.175435	0.036	1.158306	0.000	1.158980	0.001	1.160806	0.002	1.161453	0.002	1.160143	0.001	1.158561	0.000	1.158345	0.000	1.160542	0.002
0.0015	1.213008	1.215049	0.000	1.196742	0.026	1.202760	0.011	1.203801	0.008	1.204464	0.007	1.203992	0.008	1.203069	0.010	1.202503	0.011	1.200997	0.014
0.0016	1.241217	1.251243	0.010	1.234547	0.004	1.244944	0.001	1.244691	0.001	1.245541	0.002	1.245633	0.002	1.246334	0.003	1.246056	0.002	1.242611	0.000
0.0017	1.283531	1.284016	0.000	1.272338	0.013	1.284619	0.000	1.282968	0.000	1.284185	0.000	1.283910	0.000	1.285726	0.000	1.286176	0.001	1.286380	0.001
0.0018	1.325846	1.313370	0.016	1.310737	0.023	1.320565	0.003	1.318130	0.006	1.319781	0.004	1.318038	0.006	1.318689	0.005	1.319258	0.004	1.323601	0.001
0.0019	1.339950	1.339304	0.000	1.350363	0.011	1.351256	0.013	1.349740	0.010	1.351586	0.014	1.348449	0.007	1.346148	0.004	1.345463	0.003	1.342399	0.001
0.002	1.382264	1.361818	0.042	1.391834	0.009	1.374859	0.005	1.377477	0.002	1.378706	0.001	1.378015	0.002	1.378840	0.001	1.379024	0.001	1.379663	0.001
Difference			0.704		0.220		0.063		0.056		0.055		0.050		0.049		0.048		0.046

a (m)	$Y_{I\ normal}$	Polynomial (2nd order)	Difference (%)	Polynomial (3rd order)	Difference (%)	Polynomial (4th order)	Difference (%)	Polynomial (5th order)	Difference (%)	Polynomial (6th order)	Difference (%)	Polynomial (7th order)	Difference (%)	Polynomial (8th order)	Difference (%)	Polynomial (9th order)	Difference (%)	Polynomial (10th order)	Difference (%)
0.0001	-0.242602	-0.312510	0.489	-0.257886	0.023	-0.246142	0.001	-0.245016	0.001	-0.243730	0.000	-0.242830	0.000	-0.242491	0.000	-0.242709	0.000	-0.242556	0.000
0.0002	-0.332872	-0.347981	0.023	-0.327856	0.003	-0.328474	0.002	-0.329126	0.001	-0.330683	0.000	-0.332435	0.000	-0.333381	0.000	-0.332567	0.000	-0.333298	0.000
0.0003	-0.394933	-0.379709	0.023	-0.384500	0.011	-0.391299	0.001	-0.392346	0.001	-0.393587	0.000	-0.394014	0.000	-0.393746	0.000	-0.394423	0.000	-0.393387	0.000
0.0004	-0.434426	-0.407693	0.071	-0.428945	0.003	-0.437441	0.001	-0.438151	0.001	-0.438147	0.001	-0.437169	0.001	-0.436423	0.000	-0.436958	0.001	-0.436909	0.001
0.0005	-0.468277	-0.431934	0.132	-0.462319	0.004	-0.469512	0.000	-0.469620	0.000	-0.468627	0.000	-0.467386	0.000	-0.467098	0.000	-0.466767	0.000	-0.467589	0.000
0.0006	-0.490845	-0.452432	0.148	-0.485748	0.003	-0.489911	0.000	-0.489463	0.000	-0.488182	0.001	-0.487643	0.001	-0.488022	0.001	-0.487350	0.001	-0.487709	0.001
0.0007	-0.496487	-0.469187	0.075	-0.500360	0.002	-0.500827	0.002	-0.500042	0.001	-0.499144	0.001	-0.499591	0.001	-0.500242	0.001	-0.499984	0.001	-0.499460	0.001
0.0008	-0.502129	-0.482199	0.040	-0.507284	0.003	-0.504236	0.000	-0.503398	0.000	-0.503269	0.000	-0.504351	0.000	-0.504737	0.001	-0.505118	0.001	-0.504411	0.001
0.0009	-0.507771	-0.491467	0.027	-0.507645	0.000	-0.501900	0.003	-0.501275	0.004	-0.501931	0.003	-0.502984	0.002	-0.502830	0.002	-0.503458	0.002	-0.503389	0.002
0.001	-0.496487	-0.496992	0.000	-0.502572	0.004	-0.495373	0.000	-0.495143	0.000	-0.496282	0.000	-0.496711	0.000	-0.496145	0.000	-0.496442	0.000	-0.497068	0.000
0.0011	-0.485203	-0.498773	0.018	-0.493193	0.006	-0.485993	0.000	-0.486223	0.000	-0.487362	0.000	-0.486933	0.000	-0.486367	0.000	-0.486069	0.000	-0.486694	0.000
0.0012	-0.473919	-0.496812	0.052	-0.480633	0.005	-0.474888	0.000	-0.475513	0.000	-0.476169	0.001	-0.475116	0.000	-0.474962	0.000	-0.474333	0.000	-0.474264	0.000
0.0013	-0.462635	-0.491107	0.081	-0.466022	0.001	-0.462973	0.000	-0.463811	0.000	-0.463681	0.000	-0.462599	0.000	-0.462985	0.000	-0.462604	0.000	-0.461898	0.000
0.0014	-0.451352	-0.481659	0.092	-0.450485	0.000	-0.450952	0.000	-0.451737	0.000	-0.450839	0.000	-0.450392	0.000	-0.451042	0.000	-0.451300	0.000	-0.450776	0.000
0.0015	-0.440068	-0.468467	0.081	-0.435152	0.002	-0.439315	0.000	-0.439763	0.000	-0.438482	0.000	-0.439021	0.000	-0.439400	0.000	-0.440073	0.000	-0.440432	0.000
0.0016	-0.428784	-0.451533	0.052	-0.421148	0.006	-0.428342	0.000	-0.428233	0.000	-0.427240	0.000	-0.428481	0.000	-0.428192	0.000	-0.428523	0.000	-0.429345	0.000
0.0017	-0.417500	-0.430855	0.018	-0.409603	0.006	-0.418099	0.000	-0.417389	0.000	-0.417385	0.000	-0.418363	0.000	-0.417616	0.000	-0.417081	0.000	-0.417032	0.000
0.0018	-0.406217	-0.406433	0.000	-0.401642	0.002	-0.408441	0.000	-0.407394	0.000	-0.408635	0.001	-0.408209	0.000	-0.407941	0.000	-0.407264	0.000	-0.406228	0.000
0.0019	-0.400575	-0.378269	0.050	-0.398393	0.000	-0.399012	0.000	-0.398360	0.000	-0.399916	0.000	-0.398164	0.001	-0.399110	0.000	-0.399925	0.000	-0.400656	0.000
0.002	-0.389291	-0.346361	0.184	-0.400985	0.014	-0.389241	0.000	-0.390367	0.000	-0.389081	0.000	-0.389980	0.000	-0.389641	0.000	-0.389423	0.000	-0.389270	0.000
Difference			1.655		0.097		0.013		0.012		0.009		0.007		0.007		0.006		0.006

a (m)	$Y_{I\ friction}$	Polynomial (2nd order)	Difference (%)	Polynomial (3rd order)	Difference (%)	Polynomial (4th order)	Difference (%)	Polynomial (5th order)	Difference (%)	Polynomial (6th order)	Difference (%)	Polynomial (7th order)	Difference (%)	Polynomial (8th order)	Difference (%)	Polynomial (9th order)	Difference (%)	Polynomial (10th order)	Difference (%)
0.0001	0.710879	0.820886	1.210	0.758920	0.231	0.728295	0.030	0.717797	0.005	0.712637	0.000	0.710710	0.000	0.710539	0.000	0.710665	0.000	0.710905	0.000
0.0002	0.801149	0.807786	0.004	0.784957	0.026	0.786569	0.021	0.792646	0.007	0.798893	0.001	0.802646	0.000	0.803123	0.000	0.802653	0.000	0.801503	0.000
0.0003	0.835001	0.793527	0.172	0.798962	0.130	0.816693	0.034	0.826453	0.007	0.831433	0.001	0.832346	0.001	0.832211	0.001	0.832601	0.001	0.834232	0.000
0.0004	0.829359	0.778107	0.263	0.802215	0.074	0.824370	0.002	0.830989	0.000	0.830973	0.000	0.828879	0.000	0.828503	0.000	0.828812	0.000	0.828888	0.000
0.0005	0.806791	0.761526	0.205	0.795995	0.012	0.814752	0.006	0.815765	0.008	0.811779	0.002	0.809120	0.001	0.808975	0.000	0.808785	0.000	0.807491	0.000
0.0006	0.778582	0.743785	0.121	0.781579	0.001	0.792435	0.019	0.788259	0.009	0.783117	0.002	0.781963	0.001	0.782154	0.001	0.781766	0.001	0.781200	0.001
0.0007	0.756014	0.724884	0.097	0.760248	0.002	0.761464	0.003	0.754146	0.000	0.750544	0.003	0.751502	0.002	0.751829	0.002	0.751681	0.002	0.752506	0.001
0.0008	0.722163	0.704823	0.030	0.733280	0.012	0.725331	0.001	0.717526	0.002	0.717006	0.003	0.719325	0.001	0.719519	0.001	0.719738	0.001	0.720849	0.000
0.0009	0.682669	0.683601	0.000	0.701954	0.037	0.686973	0.002	0.681145	0.000	0.683775	0.000	0.686031	0.001	0.685953	0.001	0.686316	0.001	0.686425	0.001
0.001	0.648818	0.661218	0.015	0.667549	0.035	0.648776	0.000	0.646631	0.000	0.651200	0.001	0.652119	0.001	0.651834	0.001	0.652006	0.001	0.651022	0.000
0.0011	0.620609	0.637675	0.029	0.631344	0.012	0.612571	0.006	0.614716	0.003	0.619285	0.000	0.618366	0.001	0.618082	0.001	0.617910	0.001	0.616926	0.001
0.0012	0.586757	0.612972	0.069	0.594619	0.006	0.579638	0.005	0.585467	0.000	0.588097	0.000	0.585842	0.000	0.585764	0.000	0.585402	0.000	0.585511	0.000
0.0013	0.552906	0.587108	0.117	0.558651	0.003	0.550703	0.000	0.558508	0.003	0.557989	0.003	0.555671	0.001	0.555865	0.001	0.555646	0.001	0.556757	0.001
0.0014	0.530338	0.560084	0.088	0.524721	0.003	0.525938	0.002	0.533255	0.001	0.529653	0.000	0.528695	0.000	0.529023	0.000	0.529171	0.000	0.529996	0.000
0.0015	0.507771	0.531900	0.058	0.494106	0.019	0.504962	0.001	0.509139	0.000	0.503997	0.001	0.505152	0.001	0.505343	0.001	0.505730	0.000	0.505165	0.001
0.0016	0.479561	0.502555	0.053	0.468087	0.013	0.486844	0.005	0.485831	0.004	0.481845	0.001	0.484504	0.002	0.484358	0.002	0.484549	0.002	0.483256	0.001
0.0017	0.468277	0.472050	0.001	0.447941	0.041	0.470096	0.000	0.463477	0.002	0.463461	0.002	0.465555	0.001	0.465179	0.001	0.464871	0.001	0.464948	0.001
0.0018	0.445710	0.440384	0.003	0.434948	0.012	0.452679	0.005	0.442918	0.001	0.447897	0.000	0.446984	0.000	0.446849	0.000	0.446459	0.000	0.448089	0.001
0.0019	0.428784	0.407558	0.045	0.430387	0.000	0.431999	0.001	0.425922	0.001	0.432168	0.001	0.428415	0.000	0.428891	0.000	0.429361	0.000	0.428210	0.000
0.002	0.411858	0.373571	0.147	0.435537	0.056	0.404913	0.005	0.415410	0.001	0.410250	0.000	0.412177	0.000	0.412007	0.000	0.411881	0.000	0.412121	0.000
Difference			2.728		0.725		0.150		0.057		0.022		0.013		0.013		0.013		0.011

a (m)	$Y_{II\ axial}$	Polynomial (2nd order)	Difference (%)	Polynomial (3rd order)	Difference (%)	Polynomial (4th order)	Difference (%)	Polynomial (5th order)	Difference (%)	Polynomial (6th order)	Difference (%)	Polynomial (7th order)	Difference (%)	Polynomial (8th order)	Difference (%)	Polynomial (9th order)	Difference (%)	Polynomial (10th order)	Difference (%)
0.0001	-0.090270	-0.097429	0.005	-0.088377	0.000	-0.088230	0.000	-0.089748	0.000	-0.088279	0.000	-0.088475	0.000	-0.089841	0.000	-0.089881	0.000	-0.089880	0.000
0.0002	-0.112838	-0.117429	0.002	-0.114094	0.000	-0.114102	0.000	-0.113223	0.000	-0.115001	0.000	-0.114618	0.000	-0.110809	0.000	-0.110658	0.000	-0.110664	0.000
0.0003	-0.135406	-0.136702	0.000	-0.137496	0.000	-0.137581	0.000	-0.136170	0.000	-0.137587	0.000	-0.137494	0.000	-0.138572	0.001	-0.138697	0.001	-0.138689	0.001
0.0004	-0.157973	-0.155248	0.001	-0.158770	0.000	-0.158876	0.000	-0.157919	0.000	-0.157915	0.000	-0.158128	0.000	-0.161134	0.001	-0.161233	0.001	-0.161233	0.001
0.0005	-0.180541	-0.173068	0.006	-0.178102	0.001	-0.178193	0.001	-0.178046	0.001	-0.176912	0.001	-0.177182	0.001	-0.178343	0.000	-0.178282	0.001	-0.178289	0.001
0.0006	-0.191824	-0.190160	0.000	-0.195681	0.001	-0.195733	0.002	-0.196337	0.002	-0.194874	0.001	-0.194991	0.001	-0.193463	0.000	-0.193338	0.000	-0.193341	0.000
0.0007	-0.214392	-0.206526	0.006	-0.211692	0.001	-0.211698	0.001	-0.212756	0.000	-0.211731	0.001	-0.211633	0.001	-0.209014	0.003	-0.208966	0.003	-0.208962	0.003
0.0008	-0.225676	-0.222165	0.001	-0.226322	0.000	-0.226284	0.000	-0.227413	0.000	-0.227265	0.000	-0.227029	0.000	-0.225475	0.000	-0.225545	0.000	-0.225539	0.000
0.0009	-0.242602	-0.237078	0.003	-0.239759	0.001	-0.239686	0.001	-0.240529	0.000	-0.241278	0.000	-0.241048	0.000	-0.241670	0.000	-0.241786	0.000	-0.241786	0.000
0.001	-0.253885	-0.251263	0.001	-0.252188	0.000	-0.252098	0.000	-0.252408	0.000	-0.253708	0.000	-0.253615	0.000	-0.255894	0.000	-0.255949	0.000	-0.255954	0.000
0.0011	-0.265169	-0.264722	0.000	-0.263797	0.000	-0.263707	0.000	-0.263397	0.000	-0.264697	0.000	-0.264791	0.000	-0.267070	0.000	-0.267014	0.000	-0.267020	0.000
0.0012	-0.276453	-0.277454	0.000	-0.274773	0.000	-0.274701	0.000	-0.273858	0.001	-0.274607	0.000	-0.274836	0.000	-0.275458	0.000	-0.275341	0.000	-0.275341	0.000
0.0013	-0.282095	-0.289459	0.005	-0.285302	0.001	-0.285264	0.001	-0.284135	0.000	-0.283987	0.000	-0.284223	0.000	-0.282670	0.000	-0.282599	0.000	-0.282593	0.000
0.0014	-0.293379	-0.300737	0.005	-0.295571	0.000	-0.295577	0.000	-0.294519	0.000	-0.293494	0.000	-0.293591	0.000	-0.290972	0.001	-0.291020	0.001	-0.291015	0.001
0.0015	-0.304662	-0.311288	0.004	-0.305768	0.000	-0.305820	0.000	-0.305216	0.000	-0.303753	0.000	-0.303635	0.000	-0.302107	0.001	-0.302231	0.001	-0.302234	0.001
0.0016	-0.315946	-0.321113	0.003	-0.316078	0.000	-0.316168	0.000	-0.316315	0.000	-0.315180	0.000	-0.314909	0.000	-0.316070	0.000	-0.316131	0.000	-0.316138	0.000
0.0017	-0.327230	-0.330211	0.001	-0.326689	0.000	-0.326796	0.000	-0.327753	0.000	-0.327748	0.000	-0.327535	0.000	-0.330541	0.001	-0.330442	0.001	-0.330441	0.001
0.0018	-0.338514	-0.338581	0.000	-0.337787	0.000	-0.337873	0.000	-0.339284	0.000	-0.340702	0.000	-0.340795	0.001	-0.341873	0.001	-0.341747	0.001	-0.341738	0.001
0.0019	-0.349798	-0.346226	0.001	-0.349560	0.000	-0.349568	0.000	-0.350447	0.000	-0.352225	0.001	-0.352607	0.001	-0.348798	0.000	-0.348949	0.000	-0.348955	0.000
0.002	-0.361081	-0.353143	0.006	-0.362194	0.000	-0.362047	0.000	-0.360529	0.000	-0.359060	0.000	-0.358864	0.000	-0.360229	0.000	-0.360189	0.000	-0.360188	0.000
Difference			0.052		0.007		0.007		0.006		0.007		0.007		0.011		0.011		0.011

a (m)	$Y_{II\ normal}$	Polynomial (2nd order)	Difference (%)	Polynomial (3rd order)	Difference (%)	Polynomial (4th order)	Difference (%)	Polynomial (5th order)	Difference (%)	Polynomial (6th order)	Difference (%)	Polynomial (7th order)	Difference (%)	Polynomial (8th order)	Difference (%)	Polynomial (9th order)	Difference (%)	Polynomial (10th order)	Difference (%)
0.0001	-0.141047	-0.168751	0.077	-0.144228	0.001	-0.138679	0.001	-0.141320	0.000	-0.141106	0.000	-0.140572	0.000	-0.141099	0.000	-0.141051	0.000	-0.140921	0.000
0.0002	-0.203108	-0.213537	0.011	-0.204502	0.000	-0.204794	0.000	-0.203265	0.000	-0.203525	0.000	-0.204565	0.000	-0.203095	0.000	-0.203273	0.000	-0.203894	0.000
0.0003	-0.259527	-0.255064	0.002	-0.257215	0.001	-0.260428	0.000	-0.257972	0.000	-0.258179	0.000	-0.258432	0.000	-0.258848	0.000	-0.258700	0.000	-0.257819	0.000
0.0004	-0.304662	-0.293333	0.013	-0.302874	0.000	-0.306888	0.000	-0.305222	0.000	-0.305221	0.000	-0.304641	0.000	-0.305801	0.000	-0.305684	0.000	-0.305643	0.000
0.0005	-0.344156	-0.328342	0.025	-0.341983	0.000	-0.345382	0.000	-0.345127	0.000	-0.344961	0.000	-0.344224	0.000	-0.344672	0.000	-0.344744	0.000	-0.345444	0.000
0.0006	-0.378007	-0.360094	0.032	-0.375051	0.001	-0.377018	0.000	-0.378068	0.000	-0.377854	0.000	-0.377534	0.000	-0.376945	0.000	-0.377091	0.000	-0.377397	0.000
0.0007	-0.406217	-0.388586	0.031	-0.402582	0.001	-0.402802	0.001	-0.404643	0.000	-0.404493	0.000	-0.404759	0.000	-0.403748	0.001	-0.403804	0.001	-0.403358	0.001
0.0008	-0.423142	-0.413820	0.009	-0.425082	0.000	-0.423642	0.000	-0.425606	0.001	-0.425584	0.001	-0.426227	0.001	-0.425627	0.001	-0.425544	0.001	-0.424944	0.000
0.0009	-0.440068	-0.435795	0.002	-0.443059	0.001	-0.440345	0.000	-0.441811	0.000	-0.441921	0.000	-0.442546	0.001	-0.442786	0.001	-0.442649	0.001	-0.442589	0.001
0.001	-0.456994	-0.454512	0.001	-0.457017	0.000	-0.453616	0.001	-0.454156	0.001	-0.454346	0.001	-0.454601	0.001	-0.455480	0.000	-0.455415	0.000	-0.455947	0.000
0.0011	-0.468277	-0.469970	0.000	-0.467464	0.000	-0.464063	0.002	-0.463523	0.002	-0.463714	0.002	-0.463459	0.002	-0.464338	0.002	-0.464403	0.002	-0.464935	0.001
0.0012	-0.468277	-0.482169	0.019	-0.474906	0.004	-0.472192	0.002	-0.470725	0.001	-0.470835	0.001	-0.470210	0.000	-0.470449	0.000	-0.470586	0.001	-0.470527	0.001
0.0013	-0.473919	-0.491110	0.030	-0.479848	0.004	-0.478408	0.002	-0.476444	0.001	-0.476422	0.001	-0.475780	0.000	-0.475180	0.000	-0.475263	0.000	-0.474662	0.000
0.0014	-0.479561	-0.496792	0.030	-0.482797	0.001	-0.483017	0.001	-0.481176	0.000	-0.481026	0.000	-0.480760	0.000	-0.479750	0.000	-0.479694	0.000	-0.479248	0.000
0.0015	-0.485203	-0.499215	0.020	-0.484258	0.000	-0.486225	0.000	-0.485174	0.000	-0.484960	0.000	-0.485280	0.000	-0.484691	0.000	-0.484544	0.000	-0.484850	0.000
0.0016	-0.490845	-0.498380	0.006	-0.484739	0.004	-0.488137	0.001	-0.488392	0.001	-0.488226	0.001	-0.488963	0.000	-0.489411	0.000	-0.489339	0.000	-0.490038	0.000
0.0017	-0.490845	-0.494286	0.001	-0.484745	0.004	-0.488759	0.000	-0.490424	0.000	-0.490424	0.000	-0.491004	0.000	-0.492164	0.000	-0.492281	0.000	-0.492239	0.000
0.0018	-0.490845	-0.486933	0.002	-0.484782	0.004	-0.487994	0.001	-0.490450	0.000	-0.490658	0.000	-0.490405	0.000	-0.490821	0.000	-0.490968	0.000	-0.490087	0.000
0.0019	-0.485203	-0.476322	0.008	-0.485357	0.000	-0.485649	0.000	-0.487178	0.000	-0.487438	0.000	-0.486398	0.000	-0.484928	0.000	-0.484751	0.000	-0.485372	0.000
0.002	-0.479561	-0.462452	0.029	-0.486976	0.005	-0.481427	0.000	-0.478786	0.000	-0.478571	0.000	-0.479105	0.000	-0.479632	0.000	-0.479680	0.000	-0.479550	0.000
Difference			0.346		0.032		0.013		0.007		0.007		0.006		0.005		0.005		0.005

a (m)	$Y_{II\ friction}$	Polynomial (2nd order)	Difference (%)	Polynomial (3rd order)	Difference (%)	Polynomial (4th order)	Difference (%)	Polynomial (5th order)	Difference (%)	Polynomial (6th order)	Difference (%)	Polynomial (7th order)	Difference (%)	Polynomial (8th order)	Difference (%)	Polynomial (9th order)	Difference (%)	Polynomial (10th order)	Difference (%)
0.0001	0.045135	0.092393	0.223	0.053815	0.008	0.045100	0.000	0.044017	0.000	0.043870	0.000	0.044607	0.000	0.045044	0.000	0.044948	0.000	0.044965	0.000
0.0002	0.112838	0.129267	0.027	0.115054	0.000	0.115513	0.001	0.116140	0.001	0.116318	0.001	0.114883	0.000	0.113664	0.000	0.114021	0.000	0.113940	0.000
0.0003	0.174899	0.162875	0.014	0.166259	0.007	0.171305	0.001	0.172312	0.001	0.172454	0.001	0.172105	0.001	0.172450	0.001	0.172153	0.001	0.172268	0.001
0.0004	0.214392	0.193218	0.045	0.208227	0.004	0.214532	0.000	0.215215	0.000	0.215215	0.000	0.216015	0.000	0.216977	0.001	0.216743	0.001	0.216748	0.001
0.0005	0.248243	0.220295	0.078	0.241754	0.004	0.247092	0.000	0.247197	0.000	0.247083	0.000	0.248099	0.000	0.248471	0.000	0.248615	0.000	0.248525	0.000
0.0006	0.270811	0.244107	0.071	0.267637	0.001	0.270726	0.000	0.270295	0.000	0.270149	0.000	0.270590	0.000	0.270101	0.000	0.270395	0.000	0.270356	0.000
0.0007	0.287737	0.264654	0.053	0.286670	0.000	0.287017	0.000	0.286261	0.000	0.286159	0.000	0.285793	0.000	0.284955	0.001	0.285068	0.001	0.285125	0.001
0.0008	0.293379	0.281935	0.013	0.299652	0.004	0.297390	0.002	0.296584	0.001	0.296570	0.001	0.295683	0.001	0.295186	0.000	0.295020	0.000	0.295098	0.000
0.0009	0.299020	0.295951	0.001	0.307377	0.007	0.303114	0.002	0.302513	0.001	0.302588	0.001	0.301725	0.001	0.301924	0.001	0.301649	0.001	0.301657	0.001
0.001	0.307483	0.306702	0.000	0.310643	0.001	0.305301	0.000	0.305080	0.001	0.305210	0.001	0.304858	0.001	0.305587	0.000	0.305457	0.000	0.305388	0.000
0.0011	0.307483	0.314187	0.004	0.310245	0.001	0.304903	0.001	0.305125	0.001	0.305255	0.000	0.305606	0.000	0.306335	0.000	0.306465	0.000	0.306396	0.000
0.0012	0.304662	0.318406	0.019	0.306980	0.001	0.302717	0.000	0.303319	0.000	0.303394	0.000	0.304256	0.000	0.304455	0.000	0.304730	0.000	0.304738	0.000
0.0013	0.299020	0.319361	0.041	0.301644	0.001	0.299382	0.000	0.300188	0.000	0.300173	0.000	0.301059	0.000	0.300562	0.000	0.300729	0.000	0.300807	0.000
0.0014	0.296200	0.317050	0.043	0.295033	0.000	0.295379	0.000	0.296135	0.000	0.296032	0.000	0.296399	0.000	0.295561	0.000	0.295448	0.000	0.295506	0.000
0.0015	0.290558	0.311473	0.044	0.287944	0.001	0.291033	0.000	0.291464	0.000	0.291318	0.000	0.290877	0.000	0.290388	0.000	0.290093	0.000	0.290054	0.000
0.0016	0.284916	0.302631	0.031	0.281172	0.001	0.286510	0.000	0.286405	0.000	0.286292	0.000	0.285276	0.000	0.285647	0.000	0.285502	0.000	0.285412	0.000
0.0017	0.282095	0.290524	0.007	0.275515	0.004	0.281819	0.000	0.281136	0.000	0.281135	0.000	0.280335	0.000	0.281296	0.000	0.281531	0.000	0.281536	0.000
0.0018	0.276453	0.275151	0.000	0.271767	0.002	0.276812	0.000	0.275805	0.000	0.275946	0.000	0.276295	0.000	0.276640	0.000	0.276937	0.000	0.277051	0.000
0.0019	0.270811	0.256513	0.020	0.270726	0.000	0.271185	0.000	0.270557	0.000	0.270735	0.000	0.272170	0.000	0.270951	0.000	0.270594	0.000	0.270514	0.000
0.002	0.265169	0.234610	0.093	0.273188	0.006	0.264473	0.000	0.265557	0.000	0.265410	0.000	0.264673	0.000	0.265110	0.000	0.265206	0.000	0.265223	0.000
Difference			0.831		0.054		0.007		0.006		0.006		0.005		0.004		0.004		0.004

Note the sign convention of $Y_{II\ friction}$.

APPENDIX W

ANALYTICAL MODEL: K_I AND K_{II}

W.1 σ_a = 70 MPa unpeened

a (m)	$K_I \geq 0$ (MPa√m) (σ_n=10 MPa)	(σ_n=20 MPa)	(σ_n=40 MPa)	(σ_n=60 MPa)	(σ_n=80 MPa)	(σ_n=100 MPa)
0	0.000	0.000	0.000	0.000	0.000	0.000
0.000052	0.323	0.481	0.523	0.411	0.890	0.411
0.0000572	0.488	0.724	0.770	0.576	1.299	0.537
0.0000624	0.694	0.998	1.044	0.774	1.711	0.694
0.0000676	0.923	1.284	1.326	0.987	2.108	0.863
0.0000728	1.152	1.559	1.594	1.191	2.463	1.021
0.000078	1.370	1.812	1.836	1.375	2.767	1.158
0.0000832	1.576	2.045	2.054	1.541	3.026	1.274
0.0000884	1.775	2.263	2.256	1.695	3.251	1.378
0.0000936	1.971	2.473	2.448	1.844	3.456	1.479
0.0000988	2.168	2.681	2.638	1.995	3.651	1.582
0.000104	2.367	2.888	2.828	2.149	3.840	1.692
0.000156	2.568	3.095	3.018	2.307	4.026	1.808
0.000208	2.768	3.299	3.207	2.466	4.207	1.928
0.00026	2.967	3.499	3.392	2.626	4.381	2.051
0.000312	3.162	3.694	3.572	2.783	4.546	2.175
0.000364	3.353	3.883	3.747	2.938	4.703	2.299
0.000416	3.542	4.068	3.919	3.093	4.853	2.426
0.000468	3.729	4.250	4.089	3.250	5.001	2.557
0.00052	3.918	4.433	4.260	3.411	5.149	2.696
0.000572	4.110	4.618	4.435	3.578	5.301	2.844
0.000624	4.305	4.807	4.616	3.752	5.460	3.002
0.000676	4.505	5.000	4.801	3.933	5.626	3.170
0.000728	4.707	5.197	4.991	4.119	5.796	3.344
0.00078	4.910	5.393	5.181	4.307	5.968	3.521
0.000832	5.112	5.589	5.371	4.494	6.138	3.698
0.000884	5.311	5.781	5.557	4.678	6.305	3.872
0.000936	5.507	5.970	5.740	4.858	6.467	4.042
0.000988	5.701	6.158	5.921	5.038	6.627	4.211
0.00104	5.897	6.346	6.104	5.219	6.790	4.384
0.001092	6.097	6.540	6.293	5.408	6.962	4.565
0.001144	6.304	6.742	6.491	5.606	7.147	4.759
0.001196	6.517	6.952	6.699	5.815	7.345	4.964
0.001248	6.731	7.163	6.908	6.025	7.548	5.174
0.0013	6.934	7.363	7.107	6.224	7.738	5.370
0.001352	7.114	7.537	7.277	6.394	7.893	5.534
0.001404	7.261	7.675	7.407	6.523	7.998	5.651
0.001456	7.390	7.794	7.516	6.630	8.075	5.743
0.001508	7.574	7.971	7.690	6.806	8.232	5.915
0.00156	7.993	8.409	8.152	7.281	8.755	6.432

a (m)	ΔK$_{II}$ (MPa√m)					
	(σ_n=10 MPa)	(σ_n=20 MPa)	(σ_n=40 MPa)	(σ_n=60 MPa)	(σ_n=80 MPa)	(σ_n=100 MPa)
0	0.000	0.000	0.000	0.000	0.000	0.000
0.000052	-0.144	-0.150	-0.153	-0.151	-0.169	-0.154
0.0000572	-0.249	-0.287	-0.305	-0.291	-0.400	-0.310
0.0000624	-0.362	-0.443	-0.482	-0.452	-0.687	-0.492
0.0000676	-0.482	-0.614	-0.678	-0.628	-1.011	-0.694
0.0000728	-0.607	-0.794	-0.884	-0.815	-1.355	-0.908
0.000078	-0.737	-0.979	-1.096	-1.006	-1.707	-1.127
0.0000832	-0.868	-1.165	-1.308	-1.198	-2.058	-1.346
0.0000884	-1.001	-1.350	-1.519	-1.389	-2.400	-1.563
0.0000936	-1.133	-1.532	-1.724	-1.576	-2.730	-1.775
0.0000988	-1.264	-1.709	-1.924	-1.758	-3.046	-1.980
0.000104	-1.394	-1.882	-2.117	-1.936	-3.347	-2.179
0.000156	-1.521	-2.049	-2.303	-2.107	-3.634	-2.370
0.000208	-1.647	-2.211	-2.483	-2.273	-3.907	-2.555
0.00026	-1.769	-2.368	-2.657	-2.434	-4.167	-2.733
0.000312	-1.890	-2.520	-2.824	-2.590	-4.415	-2.904
0.000364	-2.008	-2.668	-2.986	-2.741	-4.652	-3.070
0.000416	-2.123	-2.812	-3.143	-2.888	-4.879	-3.231
0.000468	-2.237	-2.951	-3.295	-3.030	-5.096	-3.386
0.00052	-2.348	-3.086	-3.442	-3.168	-5.303	-3.535
0.000572	-2.457	-3.217	-3.583	-3.301	-5.499	-3.680
0.000624	-2.565	-3.344	-3.719	-3.430	-5.685	-3.818
0.000676	-2.670	-3.467	-3.851	-3.555	-5.860	-3.952
0.000728	-2.775	-3.587	-3.978	-3.676	-6.024	-4.081
0.00078	-2.879	-3.703	-4.100	-3.794	-6.179	-4.205
0.000832	-2.983	-3.818	-4.220	-3.910	-6.325	-4.326
0.000884	-3.087	-3.931	-4.337	-4.024	-6.465	-4.445
0.000936	-3.192	-4.044	-4.454	-4.138	-6.602	-4.562
0.000988	-3.299	-4.157	-4.571	-4.252	-6.737	-4.680
0.00104	-3.407	-4.272	-4.690	-4.368	-6.873	-4.800
0.001092	-3.517	-4.390	-4.811	-4.487	-7.012	-4.922
0.001144	-3.630	-4.510	-4.935	-4.608	-7.155	-5.047
0.001196	-3.745	-4.633	-5.061	-4.731	-7.301	-5.174
0.001248	-3.861	-4.757	-5.188	-4.856	-7.447	-5.302
0.0013	-3.978	-4.880	-5.314	-4.980	-7.589	-5.429
0.001352	-4.094	-5.000	-5.437	-5.101	-7.722	-5.552
0.001404	-4.209	-5.117	-5.554	-5.217	-7.843	-5.669
0.001456	-4.322	-5.229	-5.666	-5.329	-7.955	-5.781
0.001508	-4.432	-5.341	-5.779	-5.442	-8.073	-5.895
0.00156	-4.544	-5.465	-5.909	-5.567	-8.234	-6.026

W.2 σ_a = 100 MPa unpeened

a (m)	$K_I \geq 0$ (MPa√m)					
	(σ_n=10 MPa)	(σ_n=20 MPa)	(σ_n=40 MPa)	(σ_n=60 MPa)	(σ_n=80 MPa)	(σ_n=100 MPa)
0	0.000	0.000	0.000	0.000	0.000	0.000
0.000052	0.474	0.529	0.641	0.581	0.563	0.636
0.0000572	0.721	0.797	0.951	0.839	0.791	0.884
0.0000624	1.027	1.119	1.308	1.146	1.068	1.176
0.0000676	1.364	1.469	1.684	1.475	1.368	1.485
0.0000728	1.700	1.814	2.047	1.793	1.657	1.778
0.000078	2.021	2.139	2.382	2.086	1.920	2.038
0.0000832	2.324	2.443	2.689	2.353	2.158	2.270
0.0000884	2.616	2.734	2.977	2.604	2.380	2.482
0.0000936	2.903	3.018	3.255	2.848	2.597	2.686
0.0000988	3.191	3.302	3.532	3.093	2.815	2.891
0.000104	3.482	3.588	3.809	3.341	3.039	3.101
0.000156	3.775	3.876	4.088	3.592	3.268	3.317
0.000208	4.067	4.163	4.365	3.845	3.499	3.535
0.00026	4.355	4.446	4.638	4.095	3.730	3.752
0.000312	4.638	4.724	4.904	4.341	3.959	3.968
0.000364	4.915	4.995	5.164	4.583	4.185	4.180
0.000416	5.188	5.262	5.418	4.823	4.409	4.393
0.000416	5.459	5.526	5.671	5.063	4.637	4.608
0.00052	5.730	5.792	5.926	5.306	4.869	4.829
0.000572	6.006	6.063	6.186	5.557	5.111	5.060
0.000624	6.287	6.339	6.452	5.816	5.362	5.303
0.000676	6.573	6.620	6.725	6.084	5.623	5.556
0.000728	6.863	6.906	7.003	6.357	5.891	5.816
0.00078	7.154	7.193	7.282	6.632	6.161	6.080
0.000832	7.443	7.479	7.559	6.906	6.431	6.342
0.000884	7.728	7.760	7.832	7.176	6.696	6.600
0.000936	8.009	8.037	8.101	7.441	6.956	6.853
0.000988	8.287	8.311	8.367	7.703	7.214	7.104
0.00104	8.567	8.587	8.635	7.969	7.475	7.359
0.001092	8.854	8.870	8.911	8.243	7.746	7.624
0.001144	9.149	9.163	9.200	8.530	8.032	7.905
0.001196	9.454	9.466	9.499	8.829	8.330	8.201
0.001248	9.759	9.770	9.801	9.131	8.631	8.501
0.0013	10.050	10.060	10.087	9.417	8.917	8.783
0.001352	10.307	10.313	10.335	9.664	9.160	9.022
0.001404	10.517	10.519	10.531	9.856	9.347	9.200
0.001456	10.704	10.699	10.698	10.018	9.503	9.346
0.001508	10.966	10.959	10.952	10.272	9.756	9.593
0.00156	11.561	11.567	11.587	10.925	10.428	10.291

a (m)	ΔK$_{II}$ (MPa√m)					
	(σ_n=10 MPa)	(σ_n=20 MPa)	(σ_n=40 MPa)	(σ_n=60 MPa)	(σ_n=80 MPa)	(σ_n=100 MPa)
0	0.000	0.000	0.000	0.000	0.000	0.000
0.000052	-0.206	-0.208	-0.214	-0.213	-0.214	-0.218
0.0000572	-0.357	-0.373	-0.406	-0.402	-0.408	-0.432
0.0000624	-0.518	-0.553	-0.624	-0.617	-0.629	-0.682
0.0000676	-0.691	-0.747	-0.862	-0.851	-0.871	-0.957
0.0000728	-0.871	-0.951	-1.113	-1.098	-1.126	-1.247
0.000078	-1.057	-1.161	-1.371	-1.352	-1.388	-1.545
0.0000832	-1.246	-1.373	-1.631	-1.607	-1.651	-1.844
0.0000884	-1.436	-1.586	-1.889	-1.861	-1.913	-2.140
0.0000936	-1.626	-1.797	-2.143	-2.111	-2.170	-2.429
0.0000988	-1.814	-2.005	-2.391	-2.355	-2.421	-2.710
0.000104	-2.000	-2.209	-2.633	-2.593	-2.666	-2.982
0.000156	-2.183	-2.409	-2.867	-2.824	-2.903	-3.245
0.000208	-2.362	-2.604	-3.095	-3.049	-3.133	-3.499
0.00026	-2.538	-2.795	-3.315	-3.266	-3.355	-3.744
0.000312	-2.711	-2.981	-3.529	-3.478	-3.572	-3.981
0.000364	-2.880	-3.163	-3.737	-3.683	-3.781	-4.210
0.000416	-3.046	-3.341	-3.939	-3.883	-3.985	-4.432
0.000416	-3.208	-3.514	-4.135	-4.076	-4.183	-4.647
0.00052	-3.367	-3.684	-4.325	-4.265	-4.375	-4.854
0.000572	-3.524	-3.849	-4.509	-4.448	-4.561	-5.054
0.000624	-3.678	-4.012	-4.689	-4.625	-4.741	-5.247
0.000676	-3.829	-4.171	-4.863	-4.798	-4.916	-5.433
0.000728	-3.979	-4.327	-5.032	-4.966	-5.086	-5.613
0.00078	-4.128	-4.481	-5.197	-5.130	-5.253	-5.788
0.000832	-4.277	-4.634	-5.359	-5.291	-5.416	-5.958
0.000884	-4.425	-4.787	-5.520	-5.451	-5.577	-6.125
0.000936	-4.576	-4.941	-5.680	-5.611	-5.738	-6.291
0.000988	-4.728	-5.096	-5.842	-5.772	-5.899	-6.457
0.00104	-4.882	-5.253	-6.005	-5.935	-6.064	-6.626
0.001092	-5.040	-5.414	-6.173	-6.102	-6.231	-6.798
0.001144	-5.202	-5.579	-6.344	-6.272	-6.403	-6.975
0.001196	-5.366	-5.746	-6.518	-6.446	-6.578	-7.155
0.001248	-5.532	-5.916	-6.694	-6.621	-6.754	-7.336
0.0013	-5.699	-6.086	-6.869	-6.796	-6.930	-7.515
0.001352	-5.866	-6.254	-7.041	-6.967	-7.102	-7.690
0.001404	-6.029	-6.418	-7.207	-7.133	-7.268	-7.857
0.001456	-6.190	-6.579	-7.367	-7.293	-7.428	-8.017
0.001508	-6.348	-6.738	-7.527	-7.453	-7.589	-8.179
0.00156	-6.507	-6.902	-7.703	-7.628	-7.765	-8.364

W.3 σ_a = 125 MPa unpeened

a (m)	$K_I \geq 0$ (MPa√m) (σ_n=10 MPa)	(σ_n=20 MPa)	(σ_n=40 MPa)	(σ_n=60 MPa)	(σ_n=80 MPa)	(σ_n=100 MPa)
0	0.000	0.000	0.000	0.000	0.000	0.000
0.000052	0.670	0.689	0.888	0.920	0.828	0.993
0.0000572	1.025	1.044	1.334	1.364	1.201	1.438
0.0000624	1.449	1.467	1.833	1.859	1.628	1.926
0.0000676	1.906	1.921	2.352	2.370	2.078	2.425
0.0000728	2.358	2.368	2.848	2.855	2.507	2.891
0.000078	2.785	2.789	3.305	3.297	2.897	3.307
0.0000832	3.187	3.183	3.723	3.698	3.250	3.676
0.0000884	3.570	3.557	4.112	4.070	3.578	4.012
0.0000936	3.946	3.924	4.487	4.425	3.893	4.331
0.0000988	4.320	4.288	4.857	4.776	4.207	4.645
0.000104	4.696	4.655	5.226	5.126	4.524	4.959
0.000156	5.072	5.023	5.593	5.476	4.844	5.275
0.000208	5.446	5.389	5.957	5.823	5.163	5.589
0.00026	5.814	5.750	6.312	6.163	5.478	5.897
0.000312	6.174	6.102	6.658	6.494	5.787	6.198
0.000364	6.526	6.446	6.994	6.815	6.089	6.490
0.000416	6.870	6.784	7.321	7.128	6.387	6.777
0.000416	7.210	7.118	7.644	7.439	6.685	7.063
0.00052	7.551	7.453	7.968	7.751	6.986	7.353
0.000572	7.896	7.793	8.296	8.070	7.296	7.652
0.000624	8.246	8.139	8.631	8.397	7.617	7.962
0.000676	8.604	8.493	8.974	8.733	7.947	8.283
0.000728	8.965	8.851	9.323	9.074	8.285	8.612
0.00078	9.328	9.211	9.673	9.418	8.626	8.943
0.000832	9.688	9.568	10.020	9.760	8.964	9.273
0.000884	10.043	9.920	10.362	10.096	9.298	9.597
0.000936	10.392	10.266	10.697	10.425	9.625	9.914
0.000988	10.739	10.610	11.030	10.752	9.949	10.228
0.00104	11.087	10.955	11.365	11.081	10.276	10.546
0.001092	11.443	11.309	11.710	11.421	10.616	10.877
0.001144	11.812	11.676	12.069	11.778	10.972	11.227
0.001196	12.191	12.054	12.443	12.149	11.343	11.594
0.001248	12.572	12.434	12.819	12.524	11.719	11.967
0.0013	12.934	12.795	13.176	12.880	12.075	12.319
0.001352	13.253	13.113	13.485	13.185	12.380	12.617
0.001404	13.514	13.370	13.729	13.422	12.614	12.839
0.001456	13.744	13.595	13.938	13.622	12.811	13.020
0.001508	14.070	13.920	14.253	13.934	13.124	13.326
0.00156	14.816	14.677	15.042	14.745	13.951	14.182

a	ΔK$_{II}$ (MPa√m)					
(m)	(σ_n=10 MPa)	(σ_n=20 MPa)	(σ_n=40 MPa)	(σ_n=60 MPa)	(σ_n=80 MPa)	(σ_n=100 MPa)
0	0.000	0.000	0.000	0.000	0.000	0.000
0.000052	-0.260	-0.261	-0.269	-0.272	-0.270	-0.277
0.0000572	-0.461	-0.470	-0.520	-0.536	-0.526	-0.570
0.0000624	-0.681	-0.699	-0.809	-0.843	-0.822	-0.916
0.0000676	-0.916	-0.946	-1.125	-1.181	-1.146	-1.300
0.0000728	-1.164	-1.206	-1.458	-1.538	-1.489	-1.706
0.000078	-1.418	-1.473	-1.801	-1.904	-1.840	-2.122
0.0000832	-1.677	-1.744	-2.145	-2.272	-2.193	-2.539
0.0000884	-1.935	-2.015	-2.486	-2.636	-2.543	-2.950
0.0000936	-2.193	-2.283	-2.821	-2.992	-2.886	-3.350
0.0000988	-2.446	-2.547	-3.148	-3.338	-3.220	-3.738
0.000104	-2.696	-2.806	-3.465	-3.674	-3.544	-4.112
0.000156	-2.941	-3.060	-3.772	-3.998	-3.858	-4.472
0.000208	-3.180	-3.308	-4.070	-4.311	-4.161	-4.818
0.00026	-3.414	-3.550	-4.358	-4.613	-4.455	-5.151
0.000312	-3.642	-3.785	-4.636	-4.906	-4.739	-5.472
0.000364	-3.866	-4.015	-4.907	-5.189	-5.014	-5.782
0.000416	-4.084	-4.240	-5.169	-5.463	-5.281	-6.081
0.000416	-4.297	-4.459	-5.423	-5.728	-5.539	-6.370
0.00052	-4.506	-4.673	-5.669	-5.985	-5.789	-6.648
0.000572	-4.710	-4.882	-5.908	-6.233	-6.031	-6.915
0.000624	-4.910	-5.087	-6.139	-6.472	-6.265	-7.172
0.000676	-5.107	-5.287	-6.362	-6.703	-6.491	-7.418
0.000728	-5.300	-5.484	-6.579	-6.926	-6.711	-7.655
0.00078	-5.492	-5.678	-6.790	-7.143	-6.924	-7.883
0.000832	-5.681	-5.871	-6.997	-7.354	-7.132	-8.104
0.000884	-5.871	-6.062	-7.201	-7.562	-7.338	-8.319
0.000936	-6.062	-6.255	-7.404	-7.768	-7.542	-8.533
0.000988	-6.255	-6.449	-7.608	-7.975	-7.748	-8.747
0.00104	-6.451	-6.647	-7.816	-8.186	-7.956	-8.963
0.001092	-6.652	-6.849	-8.027	-8.400	-8.169	-9.184
0.001144	-6.856	-7.056	-8.244	-8.620	-8.387	-9.411
0.001196	-7.064	-7.266	-8.464	-8.844	-8.608	-9.642
0.001248	-7.275	-7.478	-8.687	-9.070	-8.832	-9.874
0.0013	-7.487	-7.691	-8.908	-9.294	-9.054	-10.103
0.001352	-7.696	-7.902	-9.124	-9.511	-9.271	-10.325
0.001404	-7.902	-8.107	-9.332	-9.720	-9.479	-10.535
0.001456	-8.102	-8.308	-9.533	-9.920	-9.680	-10.735
0.001508	-8.301	-8.507	-9.734	-10.122	-9.881	-10.939
0.00156	-8.505	-8.714	-9.958	-10.352	-10.107	-11.179

APPENDIX X

ANALYTICAL MODEL: da/dN

X.1 σ_a = 70 MPa unpeened

a (m)	$\frac{da}{dN}$ (σ_n=10 MPa)	(σ_n=20 MPa)	(σ_n=40 MPa)	(σ_n=60 MPa)	(σ_n=80 MPa)	(σ_n=100 MPa)
0	0	0	0	0	0	0
0.000052	6.111E-12	1.939E-11	2.505E-11	1.229E-11	1.303E-10	1.242E-11
0.0000572	2.544E-11	7.979E-11	9.743E-11	4.337E-11	4.882E-10	3.810E-11
0.0000624	8.130E-11	2.394E-10	2.832E-10	1.261E-10	1.315E-09	1.064E-10
0.0000676	2.053E-10	5.666E-10	6.567E-10	2.998E-10	2.844E-09	2.511E-10
0.0000728	4.244E-10	1.108E-09	1.266E-09	5.923E-10	5.180E-09	4.966E-10
0.000078	7.563E-10	1.885E-09	2.127E-09	1.017E-09	8.310E-09	8.556E-10
0.0000832	1.215E-09	2.908E-09	3.248E-09	1.582E-09	1.220E-08	1.337E-09
0.0000884	1.819E-09	4.198E-09	4.647E-09	2.304E-09	1.684E-08	1.957E-09
0.0000936	2.597E-09	5.789E-09	6.358E-09	3.208E-09	2.228E-08	2.735E-09
0.0000988	3.580E-09	7.725E-09	8.422E-09	4.323E-09	2.857E-08	3.699E-09
0.000104	4.802E-09	1.004E-08	1.088E-08	5.680E-09	3.575E-08	4.870E-09
0.000156	6.289E-09	1.277E-08	1.375E-08	7.299E-09	4.382E-08	6.266E-09
0.000208	8.058E-09	1.592E-08	1.704E-08	9.193E-09	5.273E-08	7.896E-09
0.00026	1.012E-08	1.947E-08	2.074E-08	1.136E-08	6.238E-08	9.762E-09
0.000312	1.247E-08	2.341E-08	2.483E-08	1.381E-08	7.268E-08	1.187E-08
0.000364	1.511E-08	2.774E-08	2.930E-08	1.654E-08	8.357E-08	1.422E-08
0.000416	1.807E-08	3.246E-08	3.416E-08	1.957E-08	9.504E-08	1.683E-08
0.000468	2.138E-08	3.761E-08	3.945E-08	2.292E-08	1.071E-07	1.973E-08
0.00052	2.508E-08	4.324E-08	4.523E-08	2.666E-08	1.199E-07	2.297E-08
0.000572	2.923E-08	4.943E-08	5.155E-08	3.084E-08	1.334E-07	2.658E-08
0.000624	3.389E-08	5.623E-08	5.850E-08	3.550E-08	1.477E-07	3.062E-08
0.000676	3.910E-08	6.369E-08	6.610E-08	4.070E-08	1.629E-07	3.511E-08
0.000728	4.489E-08	7.183E-08	7.436E-08	4.643E-08	1.788E-07	4.006E-08
0.00078	5.127E-08	8.062E-08	8.325E-08	5.268E-08	1.954E-07	4.545E-08
0.000832	5.820E-08	9.003E-08	9.273E-08	5.943E-08	2.124E-07	5.125E-08
0.000884	6.569E-08	1.000E-07	1.027E-07	6.665E-08	2.298E-07	5.744E-08
0.000936	7.373E-08	1.106E-07	1.133E-07	7.435E-08	2.477E-07	6.405E-08
0.000988	8.240E-08	1.219E-07	1.246E-07	8.263E-08	2.663E-07	7.115E-08
0.00104	9.184E-08	1.340E-07	1.367E-07	9.166E-08	2.862E-07	7.894E-08
0.001092	1.022E-07	1.474E-07	1.501E-07	1.017E-07	3.079E-07	8.764E-08
0.001144	1.138E-07	1.622E-07	1.649E-07	1.129E-07	3.320E-07	9.748E-08
0.001196	1.266E-07	1.784E-07	1.813E-07	1.255E-07	3.587E-07	1.086E-07
0.001248	1.404E-07	1.960E-07	1.990E-07	1.391E-07	3.872E-07	1.207E-07
0.0013	1.546E-07	2.139E-07	2.171E-07	1.532E-07	4.158E-07	1.332E-07
0.001352	1.685E-07	2.310E-07	2.342E-07	1.666E-07	4.418E-07	1.451E-07
0.001404	1.811E-07	2.462E-07	2.492E-07	1.783E-07	4.629E-07	1.553E-07
0.001456	1.932E-07	2.604E-07	2.629E-07	1.892E-07	4.810E-07	1.646E-07
0.001508	2.094E-07	2.799E-07	2.822E-07	2.046E-07	5.084E-07	1.782E-07
0.00156	2.436E-07	3.231E-07	3.272E-07	2.412E-07	5.818E-07	2.124E-07

X.2 σ_a = 100 MPa unpeened

a (m)	$\frac{da}{dN}$ (σ_n=10 MPa)	(σ_n=20 MPa)	(σ_n=40 MPa)	(σ_n=60 MPa)	(σ_n=80 MPa)	(σ_n=100 MPa)
0	0	0	0	0	0	0
0.000052	2.100E-11	2.867E-11	5.031E-11	3.788E-11	3.469E-11	4.949E-11
0.0000572	8.870E-11	1.186E-10	2.006E-10	1.424E-10	1.234E-10	1.710E-10
0.0000624	2.838E-10	3.703E-10	6.010E-10	4.235E-10	3.619E-10	4.882E-10
0.0000676	7.150E-10	9.130E-10	1.430E-09	1.015E-09	8.661E-10	1.144E-09
0.0000728	1.475E-09	1.850E-09	2.814E-09	2.014E-09	1.721E-09	2.237E-09
0.000078	2.623E-09	3.240E-09	4.812E-09	3.469E-09	2.968E-09	3.809E-09
0.0000832	4.205E-09	5.127E-09	7.457E-09	5.411E-09	4.637E-09	5.887E-09
0.0000884	6.286E-09	7.575E-09	1.081E-08	7.893E-09	6.776E-09	8.520E-09
0.0000936	8.955E-09	1.068E-08	1.497E-08	1.100E-08	9.463E-09	1.179E-08
0.0000988	1.232E-08	1.455E-08	2.007E-08	1.485E-08	1.279E-08	1.580E-08
0.000104	1.650E-08	1.929E-08	2.622E-08	1.952E-08	1.686E-08	2.065E-08
0.000156	2.156E-08	2.501E-08	3.350E-08	2.511E-08	2.173E-08	2.640E-08
0.000208	2.757E-08	3.173E-08	4.194E-08	3.165E-08	2.745E-08	3.307E-08
0.00026	3.455E-08	3.947E-08	5.153E-08	3.914E-08	3.403E-08	4.068E-08
0.000312	4.249E-08	4.823E-08	6.224E-08	4.758E-08	4.146E-08	4.921E-08
0.000364	5.142E-08	5.801E-08	7.407E-08	5.698E-08	4.976E-08	5.867E-08
0.000416	6.138E-08	6.886E-08	8.705E-08	6.739E-08	5.900E-08	6.912E-08
0.000468	7.247E-08	8.089E-08	1.013E-07	7.892E-08	6.928E-08	8.067E-08
0.00052	8.486E-08	9.425E-08	1.170E-07	9.174E-08	8.075E-08	9.346E-08
0.000572	9.872E-08	1.091E-07	1.343E-07	1.060E-07	9.359E-08	1.077E-07
0.000624	1.142E-07	1.257E-07	1.535E-07	1.220E-07	1.080E-07	1.235E-07
0.000676	1.316E-07	1.442E-07	1.746E-07	1.397E-07	1.240E-07	1.410E-07
0.000728	1.508E-07	1.646E-07	1.978E-07	1.592E-07	1.417E-07	1.603E-07
0.00078	1.719E-07	1.870E-07	2.229E-07	1.805E-07	1.611E-07	1.812E-07
0.000832	1.949E-07	2.111E-07	2.499E-07	2.036E-07	1.821E-07	2.037E-07
0.000884	2.196E-07	2.371E-07	2.786E-07	2.282E-07	2.046E-07	2.276E-07
0.000936	2.462E-07	2.648E-07	3.092E-07	2.545E-07	2.287E-07	2.530E-07
0.000988	2.748E-07	2.947E-07	3.418E-07	2.828E-07	2.545E-07	2.803E-07
0.00104	3.058E-07	3.271E-07	3.772E-07	3.135E-07	2.827E-07	3.100E-07
0.001092	3.400E-07	3.627E-07	4.161E-07	3.474E-07	3.141E-07	3.430E-07
0.001144	3.780E-07	4.022E-07	4.593E-07	3.854E-07	3.492E-07	3.800E-07
0.001196	4.198E-07	4.459E-07	5.070E-07	4.276E-07	3.885E-07	4.214E-07
0.001248	4.651E-07	4.931E-07	5.586E-07	4.733E-07	4.312E-07	4.664E-07
0.0013	5.118E-07	5.417E-07	6.115E-07	5.204E-07	4.752E-07	5.127E-07
0.001352	5.571E-07	5.886E-07	6.620E-07	5.654E-07	5.172E-07	5.565E-07
0.001404	5.984E-07	6.310E-07	7.069E-07	6.053E-07	5.542E-07	5.945E-07
0.001456	6.380E-07	6.714E-07	7.489E-07	6.426E-07	5.886E-07	6.295E-07
0.001508	6.909E-07	7.257E-07	8.066E-07	6.945E-07	6.372E-07	6.796E-07
0.00156	8.022E-07	8.428E-07	9.365E-07	8.135E-07	7.512E-07	8.010E-07

X.3 σ_a = 125 MPa unpeened

a (m)	da/dN (σ_n=10 MPa)	(σ_n=20 MPa)	(σ_n=40 MPa)	(σ_n=60 MPa)	(σ_n=80 MPa)	(σ_n=100 MPa)
0	0	0	0	0	0	0
0.000052	6.156E-11	6.666E-11	1.412E-10	1.575E-10	1.147E-10	1.989E-10
0.0000572	2.633E-10	2.794E-10	5.777E-10	6.240E-10	4.338E-10	7.428E-10
0.0000624	8.306E-10	8.714E-10	1.722E-09	1.829E-09	1.269E-09	2.110E-09
0.0000676	2.054E-09	2.139E-09	4.051E-09	4.262E-09	2.984E-09	4.828E-09
0.0000728	4.168E-09	4.314E-09	7.888E-09	8.240E-09	5.827E-09	9.218E-09
0.000078	7.309E-09	7.528E-09	1.336E-08	1.388E-08	9.901E-09	1.538E-08
0.0000832	1.158E-08	1.187E-08	2.055E-08	2.124E-08	1.526E-08	2.333E-08
0.0000884	1.712E-08	1.749E-08	2.958E-08	3.044E-08	2.203E-08	3.320E-08
0.0000936	2.413E-08	2.458E-08	4.067E-08	4.171E-08	3.040E-08	4.520E-08
0.0000988	3.287E-08	3.338E-08	5.413E-08	5.533E-08	4.061E-08	5.961E-08
0.000104	4.358E-08	4.414E-08	7.021E-08	7.155E-08	5.290E-08	7.667E-08
0.000156	5.644E-08	5.704E-08	8.907E-08	9.053E-08	6.742E-08	9.653E-08
0.000208	7.155E-08	7.217E-08	1.107E-07	1.123E-07	8.422E-08	1.192E-07
0.00026	8.891E-08	8.953E-08	1.352E-07	1.368E-07	1.033E-07	1.446E-07
0.000312	1.085E-07	1.091E-07	1.623E-07	1.639E-07	1.246E-07	1.725E-07
0.000364	1.303E-07	1.309E-07	1.919E-07	1.935E-07	1.481E-07	2.030E-07
0.000416	1.545E-07	1.550E-07	2.242E-07	2.257E-07	1.738E-07	2.361E-07
0.000416	1.812E-07	1.816E-07	2.593E-07	2.608E-07	2.021E-07	2.720E-07
0.00052	2.107E-07	2.110E-07	2.977E-07	2.991E-07	2.333E-07	3.111E-07
0.000572	2.436E-07	2.438E-07	3.397E-07	3.410E-07	2.678E-07	3.539E-07
0.000624	2.801E-07	2.802E-07	3.859E-07	3.870E-07	3.060E-07	4.007E-07
0.000676	3.206E-07	3.205E-07	4.364E-07	4.374E-07	3.481E-07	4.519E-07
0.000728	3.653E-07	3.650E-07	4.915E-07	4.922E-07	3.942E-07	5.073E-07
0.00078	4.141E-07	4.136E-07	5.509E-07	5.512E-07	4.442E-07	5.667E-07
0.000832	4.668E-07	4.660E-07	6.143E-07	6.141E-07	4.978E-07	6.297E-07
0.000884	5.234E-07	5.222E-07	6.816E-07	6.807E-07	5.549E-07	6.962E-07
0.000936	5.838E-07	5.823E-07	7.527E-07	7.511E-07	6.154E-07	7.661E-07
0.000988	6.487E-07	6.467E-07	8.285E-07	8.260E-07	6.801E-07	8.403E-07
0.00104	7.190E-07	7.166E-07	9.102E-07	9.068E-07	7.502E-07	9.205E-07
0.001092	7.961E-07	7.933E-07	9.998E-07	9.954E-07	8.276E-07	1.009E-06
0.001144	8.815E-07	8.782E-07	1.099E-06	1.094E-06	9.138E-07	1.107E-06
0.001196	9.755E-07	9.720E-07	1.208E-06	1.203E-06	1.010E-06	1.216E-06
0.001248	1.077E-06	1.073E-06	1.326E-06	1.320E-06	1.113E-06	1.334E-06
0.0013	1.181E-06	1.177E-06	1.446E-06	1.440E-06	1.220E-06	1.454E-06
0.001352	1.282E-06	1.278E-06	1.561E-06	1.553E-06	1.321E-06	1.567E-06
0.001404	1.374E-06	1.368E-06	1.662E-06	1.653E-06	1.409E-06	1.665E-06
0.001456	1.461E-06	1.455E-06	1.757E-06	1.745E-06	1.492E-06	1.753E-06
0.001508	1.578E-06	1.570E-06	1.886E-06	1.873E-06	1.607E-06	1.880E-06
0.00156	1.824E-06	1.819E-06	2.178E-06	2.168E-06	1.875E-06	2.185E-06

APPENDIX Y

ANALYTICAL MODEL: ΔN

Y.1 σ_a = 70 MPa unpeened

a (m)	ΔN (σ_n=10 MPa) (Trapezium)	(cumulative)	(Simpson's)	(cumulative)	ΔN (σ_n=20 MPa) (Trapezium)	(cumulative)	(Simpson's)	(cumulative)
0	0	0		0	0	0		0
0.000052	17018066	17018066		0	5363564	5363564		0
0.0000572	3296217	20314282	5774899.362	5774899	1048596	6412160	1835262.495	1835262
0.0000624	974344	21288626		5774899	325776	6737936		1835262
0.0000676	362932	21651558	591833.9645	6366733	129032	6866968	210406.1917	2045669
0.0000728	165162	21816720		6366733	62097	6929065		2045669
0.000078	88080	21904800	146778.5666	6513512	34745	6963810	58382.97378	2104052
0.0000832	52758	21957558		6513512	21698	6985508		2104052
0.0000884	34275	21991833	59051.29492	6572563	14636	7000144	25470.63926	2129522
0.0000936	23551	22015384		6572563	10413	7010557		2129522
0.0000988	16838	22032223	29653.31924	6602217	7696	7018253	13695.1919	2143217
0.000104	12408	22044631		6602217	5853	7024106		2143217
0.000156	9378	22054009	16786.16312	6619003	4558	7028664	8243.22364	2151461
0.000208	7249	22061258		6619003	3625	7032289		2151461
0.00026	5723	22066980	10395.70891	6629398	2939	7035228	5390.471869	2156851
0.000312	4606	22071586		6629398	2425	7037653		2156851
0.000364	3771	22075357	6937.724593	6636336	2033	7039686	3773.472963	2160625
0.000416	3134	22078491		6636336	1727	7041414		2160625
0.000468	2636	22081128	4893.582478	6641230	1484	7042898	2778.195107	2163403
0.00052	2239	22083366		6641230	1286	7044184		2163403
0.000572	1915	22085282	3574.877948	6644805	1122	7045307	2111.884275	2165515
0.000624	1648	22086929		6644805	984	7046291		2165515
0.000676	1425	22088354	2670.792867	6647475	867	7047158	1638.240022	2167153
0.000728	1238	22089592		6647475	767	7047926		2167153
0.00078	1082	22090674	2036.274591	6649512	682	7048608	1293.878775	2168447
0.000832	950	22091624		6649512	609	7049217		2168447
0.000884	839	22092463	1588.382896	6651100	547	7049765	1042.505152	2169489
0.000936	746	22093209		6651100	494	7050258		2169489
0.000988	666	22093875	1265.191154	6652365	447	7050706	854.9168159	2170344
0.00104	597	22094472		6652365	406	7051112		2170344
0.001092	536	22095008	1019.169803	6653384	370	7051482	706.6151278	2171051
0.001144	481	22095490		6653384	336	7051818		2171051
0.001196	433	22095922	823.6257769	6654208	305	7052123	583.9196939	2171635
0.001248	390	22096312		6654208	278	7052401		2171635
0.0013	353	22096664	674.7200319	6654883	254	7052655	487.6313975	2172122
0.001352	322	22096986		6654883	234	7052888		2172122
0.001404	298	22097284	575.4613877	6655458	218	7053106	423.1707476	2172546
0.001456	278	22097562		6655458	205	7053311		2172546
0.001508	258	22097820	492.0084152	6655950	192	7053504	367.9250233	2172914
0.00156	230	22098050		6655950	172	7053676		2172914

a (m)	ΔN (σ_n=40 MPa) (Trapezium)	(cumulative)	(Simpson's)	(cumulative)	ΔN (σ_n=60 MPa) (Trapezium)	(cumulative)	(Simpson's)	(cumulative)
0	0	0		0	0	0		0
0.000052	4152178	4152178		0	8461186	8461186		0
0.0000572	849117	5001295	1464841.832	1464842	1868304	10329490	3146105.895	3146106
0.0000624	273254	5274549		1464842	613505	10942996		3146106
0.0000676	110657	5385206	180489.1407	1645331	244191	11187187	397976.9593	3544083
0.0000728	54098	5439304		1645331	116586	11303773		3544083
0.000078	30652	5469956	51623.50951	1696954	64630	11368403	108402.2543	3652485
0.0000832	19347	5489303		1696954	40012	11408416		3652485
0.0000884	13172	5502475	22981.62159	1719936	26759	11435175	46448.6845	3698934
0.0000936	9450	5511925		1719936	18869	11454044		3698934
0.0000988	7036	5518961	12551.62497	1732488	13811	11467855	24494.16563	3723428
0.000104	5388	5524349		1732488	10397	11478252		3723428
0.000156	4223	5528572	7652.691551	1740140	8013	11486265	14435.72219	3737864
0.000208	3378	5531949		1740140	6306	11492571		3737864
0.00026	2753	5534702	5058.146591	1745199	5059	11497629	9241.292109	3747105
0.000312	2282	5536984		1745199	4131	11501760		3747105
0.000364	1921	5538906	3571.841366	1748770	3427	11505187	6332.812176	3753438
0.000416	1639	5540544		1748770	2880	11508067		3753438
0.000468	1413	5541957	2648.119974	1751419	2448	11510515	4560.38648	3757998
0.00052	1228	5543185		1751419	2097	11512612		3757998
0.000572	1075	5544260	2024.458893	1753443	1809	11514421	3386.477246	3761385
0.000624	945	5545205		1753443	1568	11515988		3761385
0.000676	835	5546040	1578.350744	1755021	1365	11517353	2565.174621	3763950
0.000728	740	5546780		1755021	1194	11518547		3763950
0.00078	660	5547440	1252.831724	1756274	1049	11519596	1981.015875	3765931
0.000832	591	5548031		1756274	928	11520524		3765931
0.000884	532	5548563	1014.709685	1757289	825	11521349	1565.032937	3767496
0.000936	481	5549044		1757289	738	11522086		3767496
0.000988	437	5549482	836.3114323	1758125	662	11522749	1261.315026	3768757
0.00104	398	5549880		1758125	597	11523345		3768757
0.001092	363	5550242	693.9117553	1758819	538	11523883	1024.576749	3769782
0.001144	330	5550572		1758819	485	11524368		3769782
0.001196	300	5550873	574.596697	1759394	436	11524804	830.7257652	3770612
0.001248	273	5551146		1759394	393	11525197		3770612
0.0013	250	5551396	480.4413996	1759874	356	11525553	681.2581912	3771294
0.001352	230	5551627		1759874	325	11525878		3771294
0.001404	215	5551842	418.1868814	1760292	302	11526180	584.514697	3771878
0.001456	203	5552045		1760292	283	11526463		3771878
0.001508	191	5552236	364.568483	1760657	264	11526727	502.3311182	3772381
0.00156	171	5552406		1760657	233	11526960		3772381

a (m)	ΔN (σ_n=80 MPa) (Trapezium)	(cumulative)	(Simpson's)	(cumulative)	ΔN (σ_n=100 MPa) (Trapezium)	(cumulative)	(Simpson's)	(cumulative)
0	0	0		0	0	0		0
0.000052	798138	798138		0	8375890	8375890		0
0.0000572	168159	966297	288234.8392	288235	2058786	10434676	3378708.395	3378708
0.0000624	57677	1023974		288235	719667	11154343		3378708
0.0000676	25006	1048980	40906.32844	329141	290937	11445280	473958.7177	3852667
0.0000728	12962	1061942		329141	139093	11584373		3852667
0.000078	7709	1069651	13110.50345	342252	76907	11661280	128893.9174	3981561
0.0000832	5071	1074723		342252	47425	11708705		3981561
0.0000884	3582	1078304	6316.413486	348568	31574	11740280	54735.39071	4036296
0.0000936	2659	1080963		348568	22167	11762446		4036296
0.0000988	2045	1083008	3689.751187	352258	16165	11778611	28642.91954	4064939
0.000104	1617	1084625		352258	12138	11790749		4064939
0.000156	1307	1085932	2395.584561	354653	9340	11800089	16820.56806	4081760
0.000208	1077	1087009		354653	7344	11807433		4081760
0.00026	903	1087913	1678.672818	356332	5890	11813323	10757.94108	4092518
0.000312	770	1088683		356332	4808	11818131		4092518
0.000364	666	1089348	1250.471369	357583	3987	11822118	7367.075776	4099885
0.000416	582	1089930		357583	3350	11825467		4099885
0.000468	514	1090445	974.3582607	358557	2845	11828312	5298.3123	4105183
0.00052	458	1090903		358557	2436	11830747		4105183
0.000572	411	1091314	781.814898	359339	2099	11832846	3928.826708	4109112
0.000624	370	1091684		359339	1818	11834664		4109112
0.000676	335	1092019	639.9542272	359979	1582	11836246	2973.484826	4112086
0.000728	304	1092323		359979	1384	11837630		4112086
0.00078	278	1092601	533.473538	360512	1216	11838846	2296.555003	4114382
0.000832	255	1092856		360512	1076	11839922		4114382
0.000884	235	1093091	453.2858803	360965	957	11840879	1815.909738	4116198
0.000936	218	1093309		360965	856	11841735		4116198
0.000988	202	1093511	390.8612824	361356	769	11842504	1464.620159	4117663
0.00104	188	1093700		361356	693	11843197		4117663
0.001092	175	1093875	337.94258	361694	624	11843821	1188.520264	4118851
0.001144	163	1094037		361694	562	11844383		4118851
0.001196	151	1094188	290.2625164	361985	505	11844888	959.9386314	4119811
0.001248	139	1094327		361985	454	11845341		4119811
0.0013	130	1094457	250.7322847	362235	409	11845751	783.3986956	4120594
0.001352	121	1094578		362235	374	11846124		4120594
0.001404	115	1094693	225.057272	362460	346	11846471	671.3255622	4121266
0.001456	110	1094803		362460	325	11846796		4121266
0.001508	105	1094908	202.207028	362663	303	11847099	576.0569223	4121842
0.00156	95	1095004		362663	266	11847366		4121842

Y.2 σ_a = 100 MPa unpeened

a	ΔN (σ_n=10 MPa)				ΔN (σ_n=20 MPa)				ΔN (σ_n=40 MPa)				ΔN (σ_n=60 MPa)				ΔN (σ_n=80 MPa)				ΔN (σ_n=100 MPa)			
(m)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)
0	0	0		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0		0
0.000052	4,952,048	4,952,048		0	3,627,377	3,627,377		0	2,067,135	2,067,135		0	2,745,404	2,745,404		0	2,998,058	2,998,058		0	2,101,494	2,101,494		0
0.0000572	948,017	5,900,064	1,668,059	1,668,059	706,267	4,333,644	1,236,059	1,236,059	414,461	2,481,595	718,965	718,965	576,979	3,322,383	985,495	985,495	658,006	3,656,064	1,109,593	1,109,593	471,721	2,573,215	791,258	791,258
0.0000624	279,167	6,179,231		1,668,059	212,736	4,546,380		1,236,059	129,744	2,611,340		718,965	183,780	3,506,163		985,495	214,314	3,870,378		1,109,593	157,774	2,730,989		791,258
0.0000676	104,117	6,283,349	169,785	1,837,844	81,045	4,627,425	132,125	1,368,184	51,207	2,662,547	83,486	802,451	72,300	3,578,463	117,846	1,103,341	84,688	3,955,066	138,015	1,247,608	63,709	2,794,698	103,846	895,104
0.0000728	47,490	6,330,839		1,837,844	37,645	4,665,070		1,368,184	24,503	2,687,049		802,451	34,333	3,612,797		1,103,341	40,197	3,995,263		1,247,608	30,754	2,825,452		895,104
0.000078	25,381	6,356,220	42,311	1,880,155	20,434	4,685,504	34,152	1,402,336	13,638	2,700,687	22,893	825,344	18,968	3,631,764	31,797	1,135,138	22,177	4,017,440	37,166	1,284,774	17,199	2,842,651	28,892	923,996
0.0000832	15,232	6,371,452		1,880,155	12,430	4,697,934		1,402,336	8,477	2,709,164		825,344	11,713	3,643,477		1,135,138	13,674	4,031,115		1,284,774	10,726	2,853,377		923,996
0.0000884	9,913	6,381,365	17,087	1,897,243	8,187	4,706,121	14,157	1,416,493	5,693	2,714,857	9,895	835,239	7,817	3,651,294	13,563	1,148,701	9,112	4,040,227	15,802	1,300,576	7,219	2,860,596	12,553	936,548
0.0000936	6,824	6,388,189		1,897,243	5,698	4,711,819		1,416,493	4,033	2,718,890		835,239	5,504	3,656,798		1,148,701	6,404	4,046,632		1,300,576	5,120	2,865,716		936,548
0.0000988	4,888	6,393,077	8,613	1,905,856	4,123	4,715,943	7,288	1,423,782	2,968	2,721,858	5,273	840,512	4,024	3,660,822	7,134	1,155,835	4,673	4,051,304	8,279	1,308,855	3,769	2,869,485	6,697	943,245
0.000104	3,609	6,396,686		1,905,856	3,073	4,719,016		1,423,782	2,247	2,724,105		840,512	3,026	3,663,848		1,155,835	3,507	4,054,811		1,308,855	2,853	2,872,338		943,245
0.000156	2,733	6,399,419	4,895	1,910,751	2,348	4,721,364	4,217	1,427,999	1,742	2,725,846	3,144	843,656	2,330	3,666,178	4,197	1,160,032	2,695	4,057,506	4,849	1,313,704	2,211	2,874,549	3,990	947,235
0.000208	2,117	6,401,535		1,910,751	1,833	4,723,197		1,427,999	1,379	2,727,225		843,656	1,832	3,668,010		1,160,032	2,114	4,059,620		1,313,704	1,749	2,876,298		947,235
0.00026	1,674	6,403,210	3,044	1,913,794	1,461	4,724,658	2,662	1,430,661	1,113	2,728,338	2,037	845,694	1,469	3,669,480	2,684	1,162,715	1,692	4,061,312	3,087	1,316,791	1,410	2,877,708	2,581	949,816
0.000312	1,350	6,404,560		1,913,794	1,186	4,725,843		1,430,661	914	2,729,252		845,694	1,199	3,670,679		1,162,715	1,378	4,062,689		1,316,791	1,157	2,878,865		949,816
0.000364	1,107	6,405,667	2,039	1,915,833	979	4,726,822	1,806	1,432,468	763	2,730,015	1,414	847,108	995	3,671,674	1,838	1,164,554	1,140	4,063,829	2,105	1,318,897	964	2,879,829	1,785	951,600
0.000416	922	6,406,589		1,915,833	820	4,727,642		1,432,468	646	2,730,660		847,108	836	3,672,510		1,164,554	956	4,064,786		1,318,897	814	2,880,643		951,600
0.000468	777	6,407,366	1,443	1,917,277	694	4,728,337	1,293	1,433,760	552	2,731,213	1,032	848,139	711	3,673,221	1,325	1,165,878	811	4,065,596	1,509	1,320,406	694	2,881,337	1,296	952,896
0.00052	661	6,408,027		1,917,277	594	4,728,930		1,433,760	476	2,731,689		848,139	609	3,673,830		1,165,878	693	4,066,289		1,320,406	597	2,881,934		952,896
0.000572	567	6,408,594	1,058	1,918,335	511	4,729,442	957	1,434,717	414	2,732,103	777	848,917	526	3,674,356	985	1,166,863	597	4,066,886	1,116	1,321,522	517	2,882,451	970	953,866
0.000624	488	6,409,082		1,918,335	443	4,729,884		1,434,717	361	2,732,464		848,917	456	3,674,812		1,166,863	516	4,067,402		1,321,522	450	2,882,901		953,866
0.000676	423	6,409,505	794	1,919,128	385	4,730,270	724	1,435,441	317	2,732,781	598	849,514	398	3,675,210	747	1,167,611	448	4,067,850	842	1,322,364	393	2,883,294	740	954,606
0.000728	368	6,409,873		1,919,128	337	4,730,606		1,435,441	279	2,733,061		849,514	348	3,675,558		1,167,611	391	4,068,242		1,322,364	345	2,883,639		954,606
0.00078	322	6,410,196	607	1,919,736	296	4,730,902	558	1,435,999	247	2,733,308	468	849,982	306	3,675,864	578	1,168,189	343	4,068,585	648	1,323,011	305	2,883,944	576	955,182
0.000832	284	6,410,479		1,919,736	261	4,731,163		1,435,999	220	2,733,528		849,982	271	3,676,135		1,168,189	303	4,068,888		1,323,011	270	2,884,214		955,182
0.000884	251	6,410,730	475	1,920,211	232	4,731,396	440	1,436,439	197	2,733,725	374	850,357	241	3,676,375	457	1,168,646	269	4,069,157	510	1,323,521	241	2,884,455	458	955,640
0.000936	223	6,410,953		1,920,211	207	4,731,603		1,436,439	177	2,733,902		850,357	215	3,676,591		1,168,646	240	4,069,397		1,323,521	216	2,884,672		955,640
0.000988	200	6,411,153	379	1,920,590	186	4,731,789	354	1,436,793	160	2,734,061	305	850,662	194	3,676,784	369	1,169,014	215	4,069,612	410	1,323,931	195	2,884,867	372	956,012
0.00104	179	6,411,332		1,920,590	167	4,731,956		1,436,793	145	2,734,206		850,662	174	3,676,959		1,169,014	194	4,069,806		1,323,931	176	2,885,043		956,012
0.001092	161	6,411,493	306	1,920,897	151	4,732,107	287	1,437,080	131	2,734,337	250	850,912	157	3,677,116	300	1,169,314	174	4,069,980	332	1,324,263	159	2,885,202	304	956,315
0.001144	145	6,411,638		1,920,897	136	4,732,243		1,437,080	119	2,734,456		850,912	142	3,677,258		1,169,314	157	4,070,137		1,324,263	144	2,885,346		956,315
0.001196	130	6,411,768	248	1,921,145	123	4,732,365	234	1,437,314	108	2,734,564	206	851,117	128	3,677,386	244	1,169,558	141	4,070,278	268	1,324,531	130	2,885,476	247	956,563
0.001248	118	6,411,886		1,921,145	111	4,732,476		1,437,314	98	2,734,661		851,117	115	3,677,502		1,169,558	127	4,070,405		1,324,531	117	2,885,593		956,563
0.0013	106	6,411,992	204	1,921,349	101	4,732,576	193	1,437,507	89	2,734,750	171	851,288	105	3,677,606	200	1,169,758	115	4,070,519	220	1,324,750	106	2,885,699	204	956,766
0.001352	97	6,412,090		1,921,349	92	4,732,669		1,437,507	82	2,734,832		851,288	96	3,677,702		1,169,758	105	4,070,624		1,324,750	97	2,885,796		956,766
0.001404	90	6,412,180	174	1,921,523	85	4,732,754	165	1,437,672	76	2,734,908	147	851,435	89	3,677,791	172	1,169,931	97	4,070,721	188	1,324,939	90	2,885,887	175	956,942
0.001456	84	6,412,264		1,921,523	80	4,732,834		1,437,672	71	2,734,979		851,435	83	3,677,874		1,169,931	91	4,070,812		1,324,939	85	2,885,972		956,942
0.001508	78	6,412,342	149	1,921,672	74	4,732,908	142	1,437,814	67	2,735,046	128	851,563	78	3,677,952	148	1,170,079	85	4,070,897	161	1,325,100	79	2,886,051	151	957,093
0.00156	70	6,412,412		1,921,672	66	4,732,974		1,437,814	60	2,735,106		851,563	69	3,678,021		1,170,079	75	4,070,972		1,325,100	70	2,886,121		957,093

Y.3 σ_a = 125 MPa unpeened

a	ΔN (σ_n=10 MPa)				ΔN (σ_n=20 MPa)			
(m)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)
0	0	0		0	0	0		0
0.000052	1,689,289	1,689,289		0	1,560,139	1,560,139		0
0.0000572	320,174	2,009,463	565,781	565,781	300,523	1,860,663	528,063	528,063
0.0000624	95,073	2,104,536		565,781	90,372	1,951,034		528,063
0.0000676	36,050	2,140,586	58,777	624,558	34,551	1,985,585	56,328	584,392
0.0000728	16,714	2,157,300		624,558	16,118	2,001,703		584,392
0.000078	9,062	2,166,362	15,142	639,700	8,783	2,010,485	14,688	599,080
0.0000832	5,506	2,171,868		639,700	5,360	2,015,845		599,080
0.0000884	3,624	2,175,492	6,266	645,965	3,542	2,019,387	6,129	605,209
0.0000936	2,521	2,178,013		645,965	2,472	2,021,860		605,209
0.0000988	1,824	2,179,838	3,225	649,190	1,794	2,023,654	3,175	608,384
0.000104	1,360	2,181,198		649,190	1,341	2,024,995		608,384
0.000156	1,040	2,182,238	1,868	651,059	1,028	2,026,023	1,848	610,232
0.000208	813	2,183,050		651,059	805	2,026,828		610,232
0.00026	648	2,183,698	1,182	652,241	643	2,027,471	1,173	611,406
0.000312	527	2,184,225		652,241	524	2,027,995		611,406
0.000364	435	2,184,661	804	653,045	433	2,028,428	800	612,206
0.000416	365	2,185,026		653,045	364	2,028,792		612,206
0.000416	310	2,185,336	577	653,622	309	2,029,101	576	612,782
0.00052	265	2,185,601		653,622	265	2,029,366		612,782
0.000572	229	2,185,830	429	654,050	229	2,029,594	428	613,210
0.000624	199	2,186,028		654,050	198	2,029,793		613,210
0.000676	173	2,186,201	326	654,376	173	2,029,966	326	613,536
0.000728	152	2,186,353		654,376	152	2,030,118		613,536
0.00078	133	2,186,487	252	654,628	134	2,030,251	252	613,788
0.000832	118	2,186,605		654,628	118	2,030,370		613,788
0.000884	105	2,186,710	199	654,827	105	2,030,475	200	613,988
0.000936	94	2,186,804		654,827	94	2,030,569		613,988
0.000988	84	2,186,888	161	654,988	85	2,030,654	161	614,149
0.00104	76	2,186,964		654,988	76	2,030,730		614,149
0.001092	69	2,187,033	131	655,119	69	2,030,799	131	614,281
0.001144	62	2,187,095		655,119	62	2,030,861		614,281
0.001196	56	2,187,151	107	655,226	56	2,030,917	107	614,388
0.001248	51	2,187,201		655,226	51	2,030,968		614,388
0.0013	46	2,187,247	88	655,314	46	2,031,014	89	614,476
0.001352	42	2,187,290		655,314	42	2,031,057		614,476
0.001404	39	2,187,329	76	655,390	39	2,031,096	76	614,553
0.001456	37	2,187,365		655,390	37	2,031,133		614,553
0.001508	34	2,187,400	65	655,455	34	2,031,167	66	614,618
0.00156	31	2,187,430		655,455	31	2,031,198		614,618

a	ΔN (σ_n=40 MPa)				ΔN (σ_n=60 MPa)			
(m)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)
0	0	0		0	0	0		0
0.000052	736,594	736,594		0	660,202	660,202		0
0.0000572	144,667	881,261	252,847	252,847	133,065	793,266	230,612	230,612
0.0000624	45,222	926,483		252,847	42,391	835,657		230,612
0.0000676	18,014	944,497	29,377	282,224	17,074	852,731	27,848	258,459
0.0000728	8,711	953,207		282,224	8,319	861,050		258,459
0.000078	4,893	958,101	8,229	290,452	4,701	865,751	7,914	266,373
0.0000832	3,066	961,167		290,452	2,961	868,712		266,373
0.0000884	2,075	963,242	3,614	294,066	2,012	870,724	3,509	269,882
0.0000936	1,480	964,722		294,066	1,441	872,166		269,882
0.0000988	1,097	965,819	1,954	296,020	1,072	873,237	1,911	271,793
0.000104	836	966,656		296,020	820	874,057		271,793
0.000156	653	967,309	1,182	297,202	642	874,699	1,162	272,955
0.000208	520	967,829		297,202	513	875,211		272,955
0.00026	423	968,252	776	297,978	417	875,629	767	273,722
0.000312	350	968,602		297,978	346	875,975		273,722
0.000364	294	968,895	545	298,523	291	876,266	541	274,263
0.000416	250	969,145		298,523	248	876,514		274,263
0.000416	215	969,360	403	298,926	214	876,728	401	274,664
0.00052	187	969,547		298,926	186	876,913		274,664
0.000572	163	969,710	307	299,234	162	877,076	306	274,970
0.000624	143	969,854		299,234	143	877,219		274,970
0.000676	126	969,980	239	299,473	126	877,345	239	275,208
0.000728	112	970,092		299,473	112	877,457		275,208
0.00078	100	970,192	189	299,662	100	877,556	189	275,398
0.000832	89	970,281		299,662	89	877,646		275,398
0.000884	80	970,361	153	299,815	80	877,726	153	275,551
0.000936	73	970,434		299,815	73	877,799		275,551
0.000988	66	970,500	126	299,941	66	877,865	126	275,677
0.00104	60	970,559		299,941	60	877,925		275,677
0.001092	54	970,614	104	300,045	55	877,979	105	275,782
0.001144	50	970,663		300,045	50	878,029		275,782
0.001196	45	970,709	86	300,131	45	878,074	87	275,868
0.001248	41	970,750		300,131	41	878,116		275,868
0.0013	38	970,787	72	300,203	38	878,153	72	275,941
0.001352	35	970,822		300,203	35	878,188		275,941
0.001404	32	970,854	63	300,266	32	878,220	63	276,004
0.001456	30	970,884		300,266	31	878,251		276,004
0.001508	29	970,913	55	300,321	29	878,280	55	276,059
0.00156	26	970,939		300,321	26	878,305		276,059

a	ΔN (σ_n=80 MPa)				ΔN (σ_n=100 MPa)			
(m)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)	(Trapezium)	(cumulative)	(Simpson's)	(cumulative)
0	0	0		0	0	0		0
0.000052	906,489	906,489		0	522,977	522,977		0
0.0000572	189,593	1,096,082	324,560	324,560	110,442	633,420	188,716	188,716
0.0000624	61,068	1,157,149		324,560	36,450	669,869		188,716
0.0000676	24,449	1,181,599	39,862	364,423	14,988	684,857	24,453	213,169
0.0000728	11,802	1,193,401		364,423	7,404	692,262		213,169
0.000078	6,612	1,200,013	11,113	375,536	4,229	696,490	7,133	220,302
0.0000832	4,133	1,204,146		375,536	2,687	699,177		220,302
0.0000884	2,789	1,206,935	4,853	380,388	1,840	701,017	3,215	223,517
0.0000936	1,984	1,208,918		380,388	1,327	702,344		223,517
0.0000988	1,464	1,210,383	2,605	382,993	992	703,336	1,773	225,289
0.000104	1,112	1,211,495		382,993	763	704,099		225,289
0.000156	864	1,212,359	1,562	384,555	600	704,700	1,090	226,379
0.000208	686	1,213,045		384,555	482	705,182		226,379
0.00026	555	1,213,600	1,016	385,571	394	705,576	725	227,105
0.000312	456	1,214,056		385,571	328	705,904		227,105
0.000364	381	1,214,437	707	386,279	277	706,181	515	227,620
0.000416	323	1,214,761		386,279	237	706,418		227,620
0.000416	277	1,215,037	517	386,796	205	706,623	384	228,004
0.00052	239	1,215,276		386,796	178	706,801		228,004
0.000572	208	1,215,483	390	387,185	156	706,957	295	228,299
0.000624	181	1,215,665		387,185	138	707,095		228,299
0.000676	159	1,215,824	300	387,485	122	707,217	231	228,530
0.000728	140	1,215,964		387,485	108	707,326		228,530
0.00078	124	1,216,088	235	387,720	97	707,422	184	228,714
0.000832	110	1,216,198		387,720	87	707,509		228,714
0.000884	99	1,216,297	188	387,908	78	707,588	150	228,864
0.000936	89	1,216,386		387,908	71	707,659		228,864
0.000988	80	1,216,466	153	388,061	65	707,724	124	228,988
0.00104	73	1,216,539		388,061	59	707,783		228,988
0.001092	66	1,216,605	126	388,187	54	707,837	103	229,091
0.001144	60	1,216,665		388,187	49	707,886		229,091
0.001196	54	1,216,719	103	388,290	45	707,931	86	229,177
0.001248	49	1,216,768		388,290	41	707,971		229,177
0.0013	45	1,216,812	86	388,376	37	708,009	72	229,248
0.001352	41	1,216,853		388,376	34	708,043		229,248
0.001404	38	1,216,891	74	388,450	32	708,075	63	229,311
0.001456	36	1,216,927		388,450	30	708,106		229,311
0.001508	34	1,216,961	64	388,514	29	708,134	55	229,366
0.00156	30	1,216,991		388,514	26	708,160		229,366

APPENDIX Z

ANALYTICAL MODEL: $K_{RESIDUAL}$

a	=	1.976 mm
K_I	=	-5.077 MPa√m

b	=	20 mm
a/b	=	0.099
g_1	=	1.267
g_2	=	-0.034
g_3	=	-0.667
g_4	=	0.289

RS effect	=	1

θ	c (asinθ)	P (poly)	P (linear)	P c<>0.44	Integrand	Simpson
0.000	0.000	-389.654	-145.922	-389.654	-1.140	
0.039	0.078	-291.129	-138.987	-291.129	-0.850	-0.068
0.079	0.155	-213.872	-132.064	-213.872	-0.623	
0.118	0.232	-161.697	-125.162	-161.697	-0.468	-0.038
0.157	0.309	-132.347	-118.291	-132.347	-0.381	
0.196	0.385	-117.749	-111.464	-117.749	-0.336	-0.026
0.236	0.461	-104.444	-104.689	-104.689	-0.297	
0.275	0.536	-74.180	-97.978	-97.978	-0.275	-0.022
0.314	0.611	-4.642	-91.341	-91.341	-0.253	
0.353	0.684	129.701	-84.789	-84.789	-0.232	-0.018
0.393	0.756	356.644	-78.330	-78.330	-0.212	
0.432	0.827	705.229	-71.976	-71.976	-0.192	-0.015
0.471	0.897	1204.690	-65.735	-65.735	-0.173	
0.511	0.966	1883.376	-59.619	-59.619	-0.155	-0.012
0.550	1.032	2767.693	-53.635	-53.635	-0.137	
0.589	1.098	3881.097	-47.794	-47.794	-0.121	-0.009
0.628	1.161	5243.144	-42.104	-42.104	-0.105	
0.668	1.223	6868.656	-36.574	-36.574	-0.089	-0.007
0.707	1.283	8766.990	-31.213	-31.213	-0.075	
0.746	1.341	10941.460	-26.028	-26.028	-0.062	-0.005
0.785	1.397	13388.905	-21.029	-21.029	-0.049	
0.825	1.451	16099.437	-16.222	-16.222	-0.037	-0.003
0.864	1.503	19056.356	-11.615	-11.615	-0.026	
0.903	1.552	22236.245	-7.215	-7.215	-0.016	-0.001
0.942	1.599	25609.252	-3.029	-3.029	-0.007	
0.982	1.643	29139.536	0.937	0.937	0.002	0.000
1.021	1.685	32785.879	4.676	4.676	0.010	
1.060	1.724	36502.446	8.183	8.183	0.017	0.001
1.100	1.761	40239.674	11.453	11.453	0.024	
1.139	1.794	43945.270	14.480	14.480	0.030	0.002
1.178	1.826	47565.289	17.259	17.259	0.036	
1.217	1.854	51045.282	19.787	19.787	0.041	0.003
1.257	1.879	54331.452	22.059	22.059	0.045	
1.296	1.902	57371.835	24.073	24.073	0.049	0.004
1.335	1.921	60117.434	25.824	25.824	0.052	
1.374	1.938	62523.306	27.310	27.310	0.055	0.004
1.414	1.952	64549.563	28.529	28.529	0.057	
1.453	1.962	66162.266	29.480	29.480	0.058	0.005
1.492	1.970	67334.188	30.159	30.159	0.060	
1.532	1.974	68045.429	30.568	30.568	0.060	0.005
1.571	1.976	68283.867	30.704	30.704	0.061	
						-0.200

a (mm)	K_I MPa√m
0.000	0.000
0.065	-5.875
0.068	-5.924
0.070	-5.971
0.072	-6.016
0.075	-6.060
0.079	-6.144
0.084	-6.223
0.089	-6.296
0.093	-6.365
0.098	-6.430
0.103	-6.491
0.112	-6.600
0.121	-6.697
0.131	-6.781
0.140	-6.854
0.149	-6.918
0.159	-6.974
0.168	-7.023
0.177	-7.064
0.187	-7.101
0.196	-7.132
0.205	-7.159
0.215	-7.182
0.224	-7.202
0.233	-7.220
0.243	-7.235
0.252	-7.249
0.271	-7.272
0.289	-7.291
0.308	-7.310
0.327	-7.328
0.345	-7.347
0.364	-7.366
0.377	-7.381
0.390	-7.396
0.403	-7.411
0.416	-7.425
0.442	-7.446
0.468	-7.452
0.494	-7.472
0.520	-7.493
0.546	-7.514
0.572	-7.531
0.598	-7.550
0.624	-7.565
0.650	-7.578
0.676	-7.587
0.702	-7.595
0.728	-7.598
0.754	-7.603
0.780	-7.602
0.832	-7.593
0.884	-7.574
0.936	-7.543
0.988	-7.504
1.040	-7.456
1.092	-7.394
1.144	-7.327
1.196	-7.249
1.248	-7.162
1.300	-7.061
1.352	-6.959
1.404	-6.847
1.456	-6.724
1.508	-6.596
1.560	-6.459
1.612	-6.312
1.664	-6.152
1.716	-5.993
1.768	-5.826
1.820	-5.651
1.872	-5.467
1.924	-5.273
1.976	-5.077