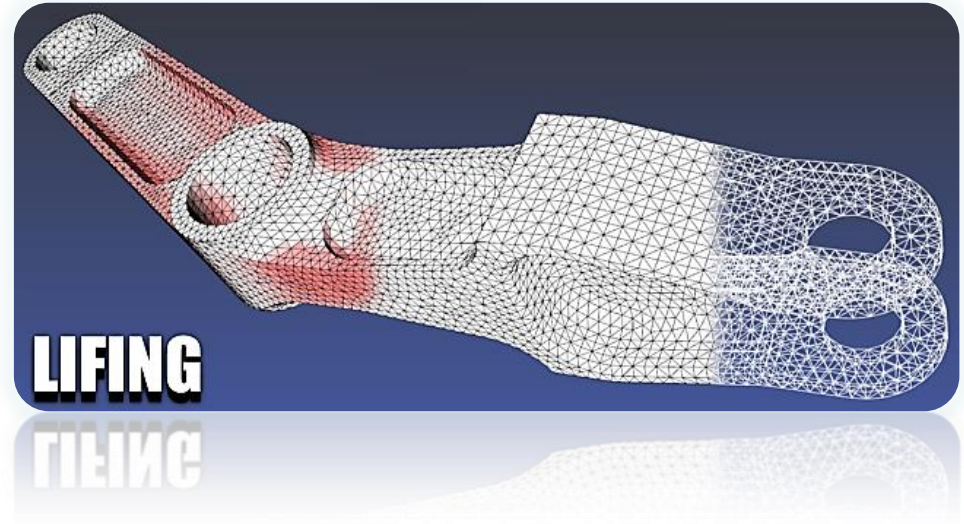


LIFING
PIPING

Outlook

- What is LIFING
- FEM interfaces
- User Interface and Post-processing capabilities
- LIFING
- LIFING.Growth
- LIFING.History



What is LIFING

- LIFING is a software for performing Fatigue and Damage Tolerance (F-DT) FEM based analysis of components
- LIFING includes a FEM Pre and Post-processor; it has interfaces for
 - NASTRAN™
 - ABAQUS™
- LIFING analysis and post-processing capabilities are tailored for F-DT analyses. Included modules are:
 - **LIFING** Multiaxial Fatigue analysis stress or strain based (also weldings, both seam welds and spot welds, are analyzed)
 - **LIFING.Growth** Crack Growth analysis in thin components
 - **LIFING.History** Spectrum files handling, counting, visualizing

User Interface and Post-processing capabilities

STRUCTLIFE - CATEST\assy.fat

Preferences Modules Help

STRUCTLIFE - FEM Fatigue

Plot-Show

Materials and spectrum definition

ANALYSIS DATA VALUE

ANALYSIS ID assy

ANALYSIS TYPE Strain based

ANALYSIS METHOD CP

PLASTICITY CALC. Neuber

FATIGUE METHOD SWT

SEQUENCE FILTERS OFF

LCF-HCF MODE Step function

LCF-HCF COMB. LCF, HCF decoupled

MATERIAL ID 2024-T3 SHEET PR...

SEQUENCE LIFE 1

GLOBAL SCALE FACT. 1

ANALYZE LOCATION All FEM

FEM

- LAYERS (3)
- FACETS (40370)
- ELEMENTS (38558)
- GRIDS (20167)
- MATERIALS (8)
 - 2024-T3 SHEET PRESTRAINED
 - 6061-T6, SHEET, SU-314 MPA
 - AISI 4130, QT, 253/265HB (SOF)
 - AISI 4340, HR, 237/247HB, UTS
 - PADO TRAINING
 - PH13-8MO
 - TESTTEST
 - TI-6AL-4V ANNEALED - BOLLE
- NOTES (0)
- LCS (4)
 - 1
 - 2
 - 3
 - 4

Material Curves

Material title: **2024-T3 SHEET PRESTRAINED - BOLLER-SEEGER P115**

Material format: EN COEFFS

Analysis units: mm-MPa

E: 74500

n': 0.04

K': 590

σf': 1044

σf: 1.765

b: -0.114

c: -0.927

Prop. Limit: 213

FTu: 450

Poisson ratio: 0.33

Show curve: Strain-Stress (Rambert-Osgood)

Element Stress Tensor data

Element Face Select 1

Element 420780 Surface Sigma XX facet 1

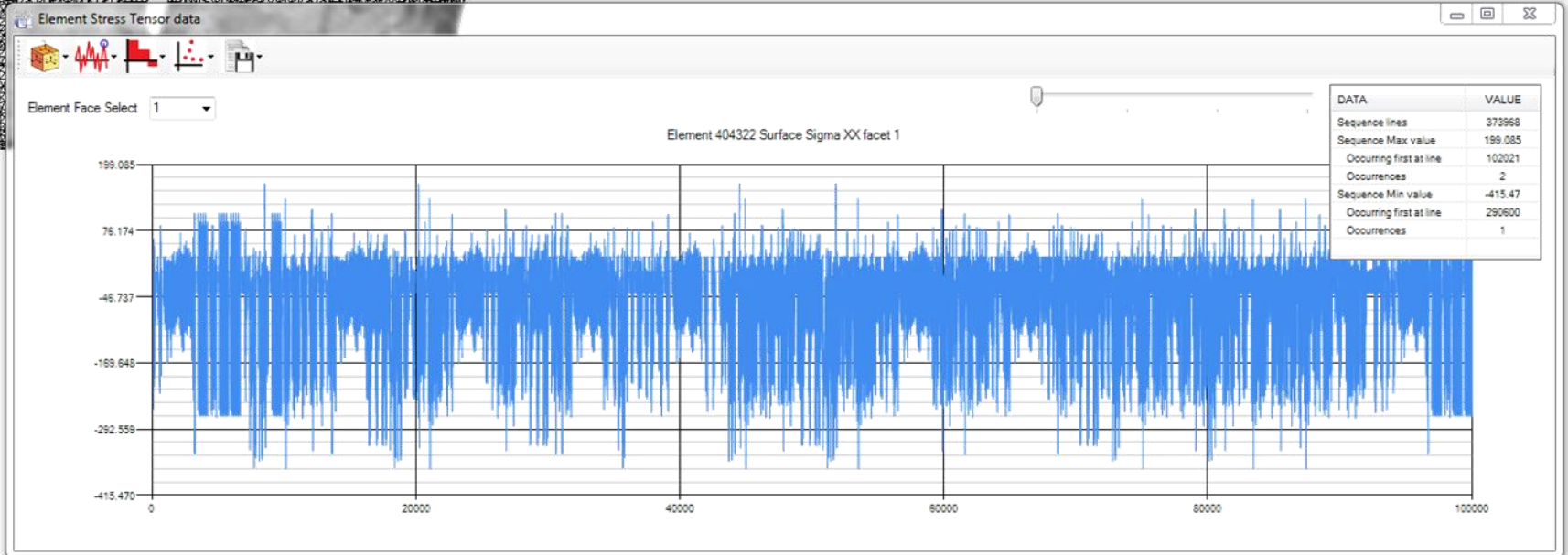
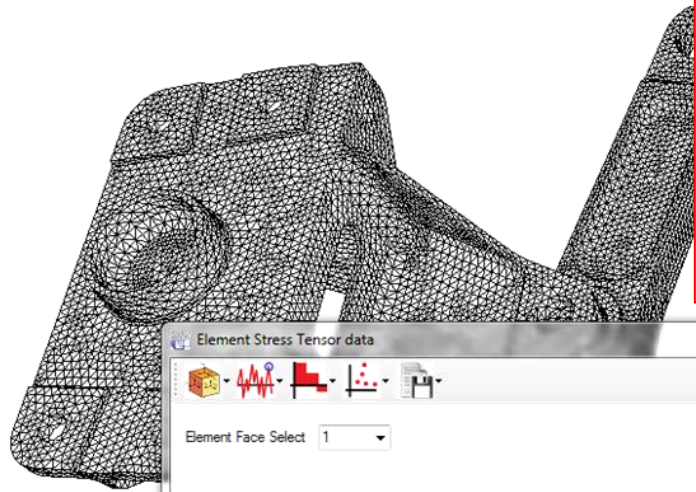
DATA	VALUE
Sequence lines	12
Sequence Max value	128.044
Occurring first at line	7
Occurrences	1
Sequence Min value	-123.842
Occurring first at line	8
Occurrences	1

Customizable material databases

file lines: 12
 Analysis file successfully imported
 Selection Mode ON
 Press CTRL key and select (Left Mouse button) in order to have fixed text
 Press SHIFT key, select (Left Mouse button) and move Mouse in order to have continuous selection
 Press ALT key and select (Left Mouse button) in order to deselect elements

User Interface and Post-processing capabilities

Each Element can be interrogated to extract stress tensor time histories (like putting virtual strain gauges and extracting stress sequences in user defined directions)



User Interface and Post-processing capabilities

Max value: 5.99300 @ Element 435753
Min value: 3.02255 @ Element 442501

5.99300
5.56865
5.14430
4.71995
4.29560
3.87125
3.44690

Calculation and visualization of fatigue critical locations and calculated initial crack

Element=442501 Layer=2
Fat.Res=1.053e+03
Life=3.0225

Analysis result files
dumped for traceability

SQLite database
generated with model
and results

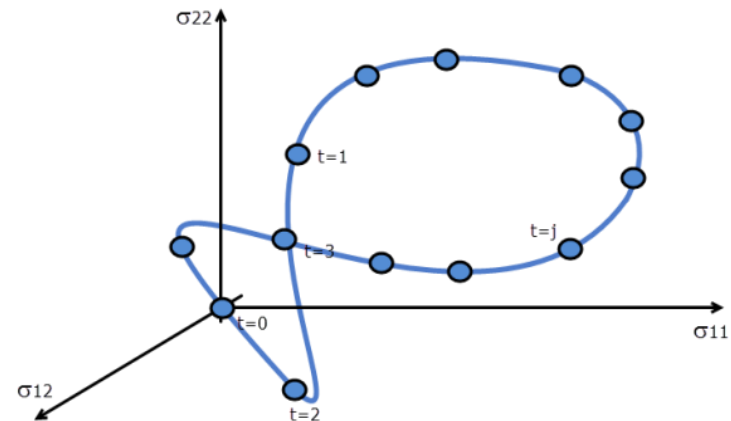
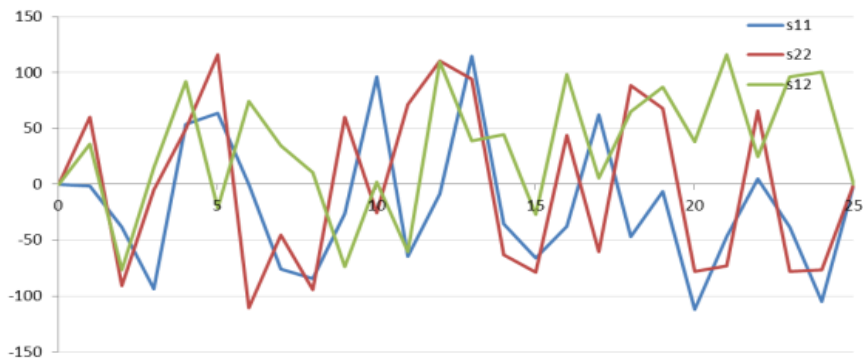
Element=442501 Layer=2
Fat.Res=1.053e+03
Log10(Life)=3.0225

LIFING

- LIFING calculates fatigue, in general crack initiation, in a FEM component or assembly
- The analysis can be conducted with multiple methods:
 - Stress based methods
 - Strain based methods
- The calculation, being based on FEM data, always involves multiaxial fatigue

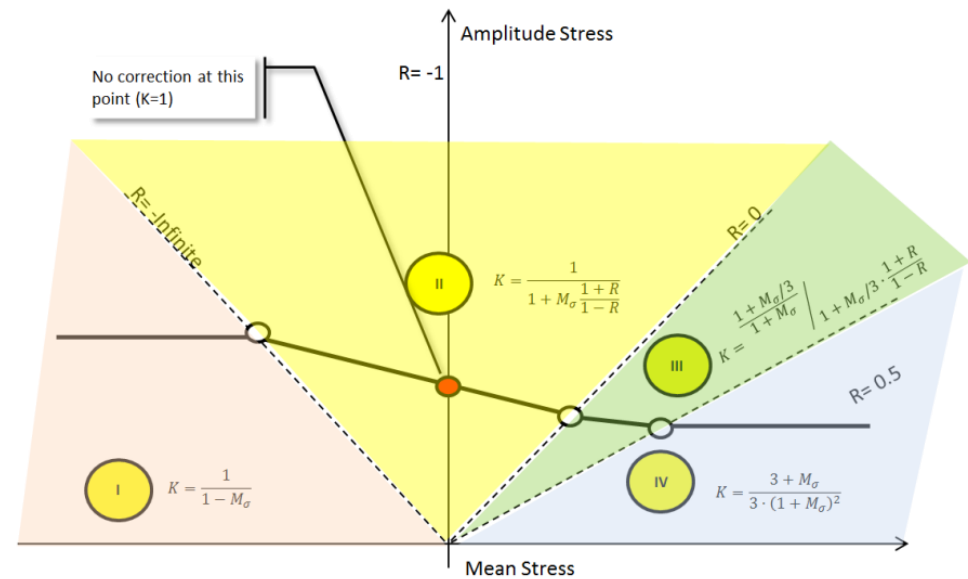
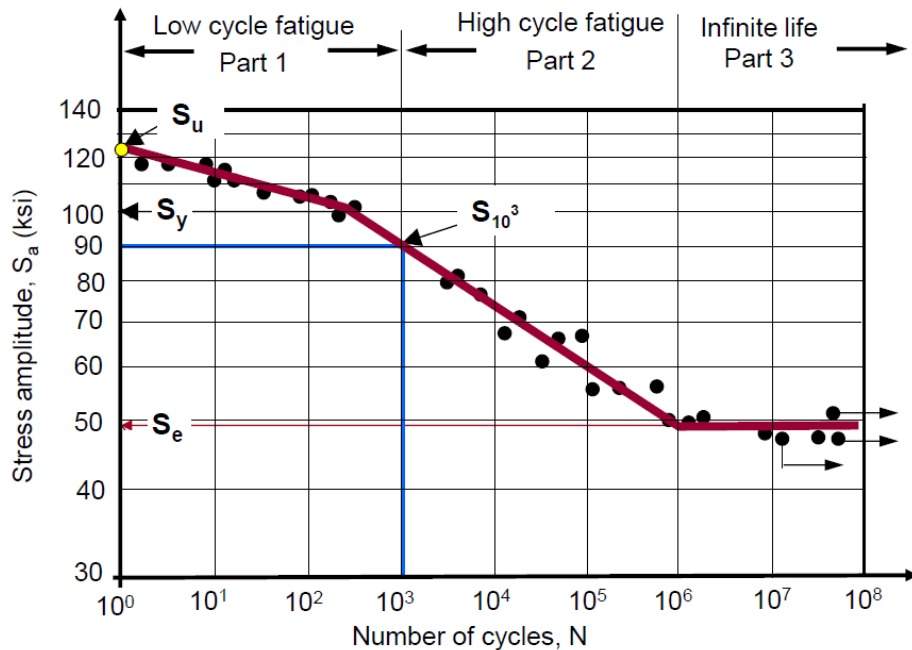
LIFING

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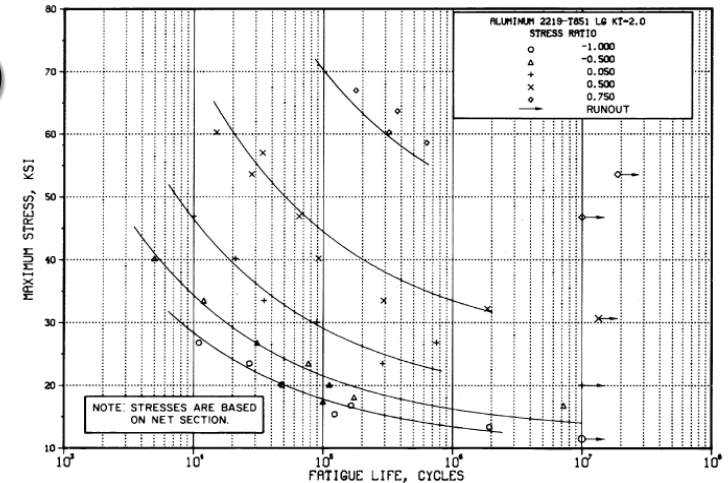
LIFING

- Stress Based Fatigue
 - SN curves based analysis
 - Goodman, Gerber, Soderberg, Haigh, ...



LIFING

- Stress Based Fatigue
 - SN curves based analysis (ASTM format)
 - MIL-HDBK material database available



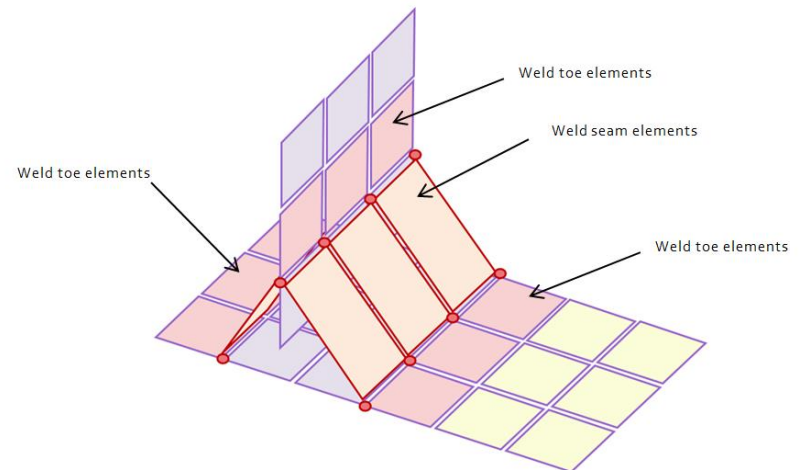
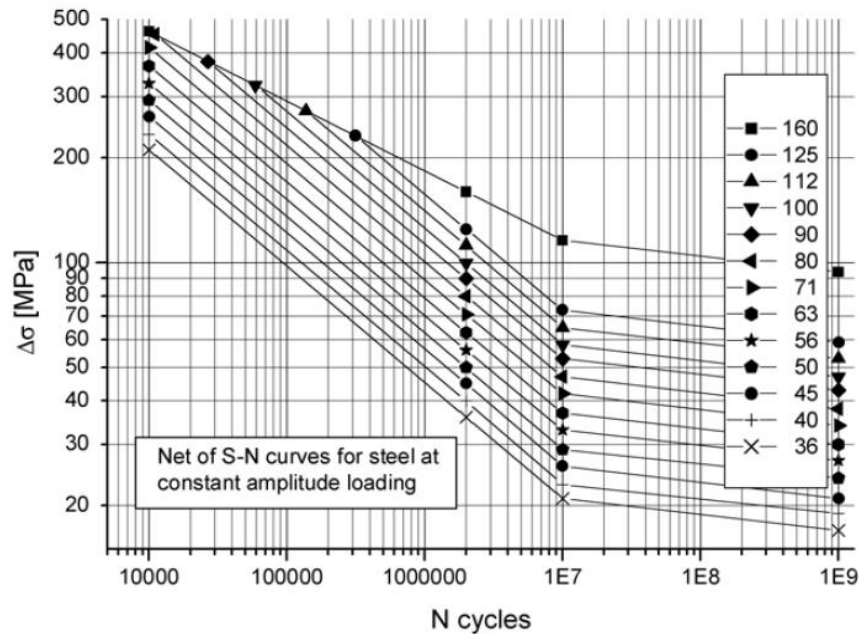
- Multiaxial Fatigue based on Equivalent Stress
 - Maximum Principal Stress
 - Sines Stress
- Dang Van method for fatigue Reserve Factor calculation (endurance)

LIFING

- Stress Based Fatigue

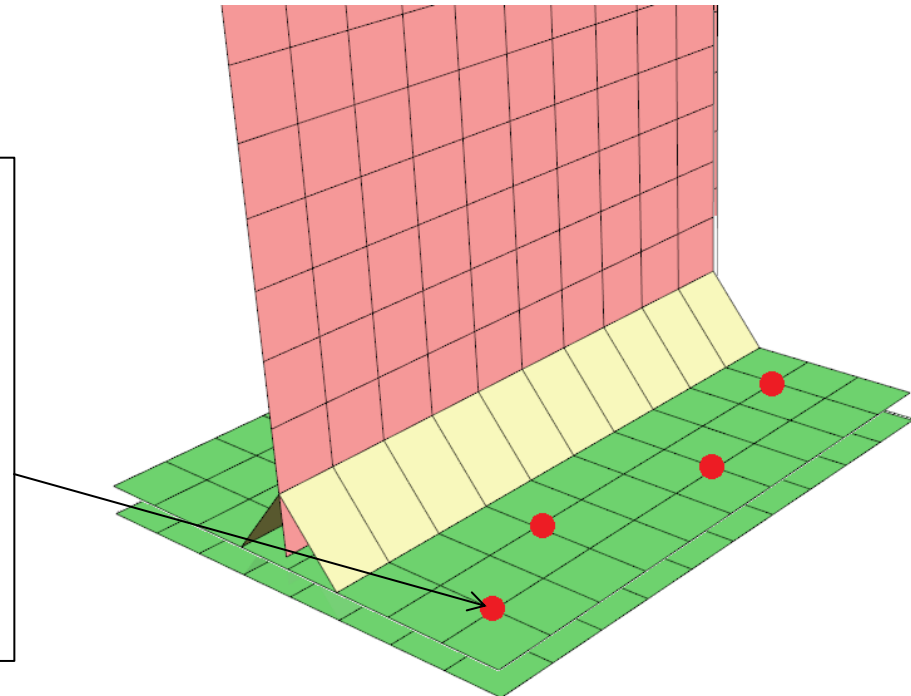
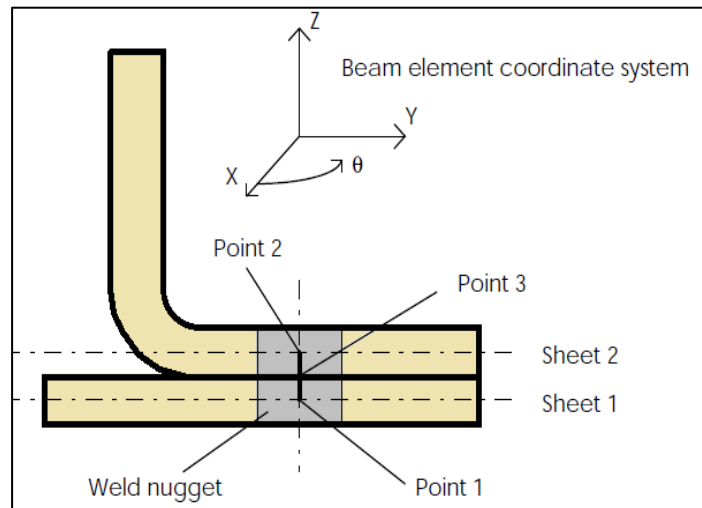
- Weldings are analyzed:

- Seam welds: International Institute of Weldings IIW-1823-07 method implemented



LIFING

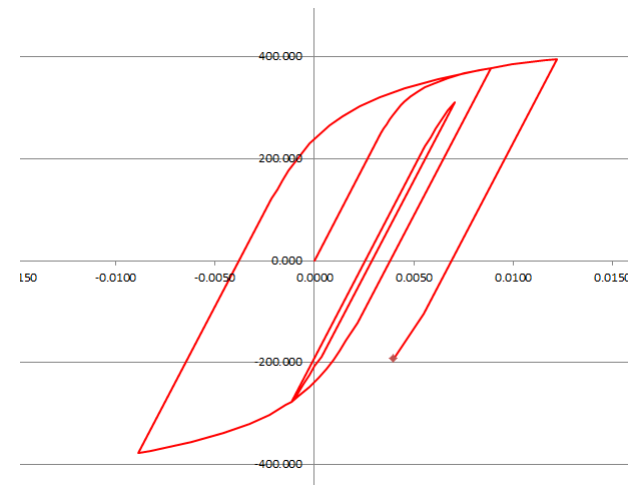
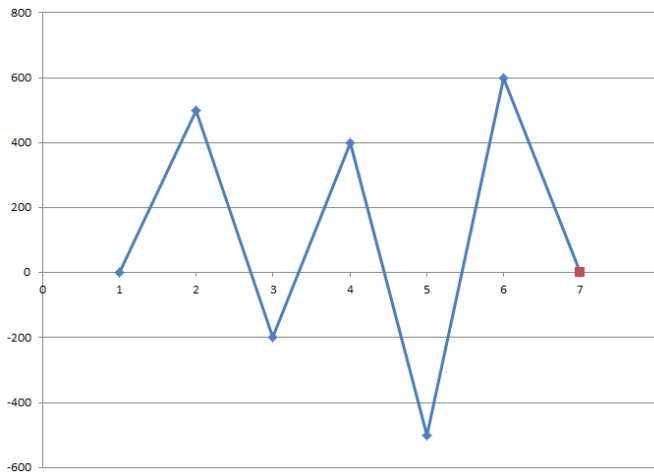
- Stress Based Fatigue
 - Weldings are analyzed:
 - Spot welds: LBF Rupp method implemented



LIFING

- Strain Based Fatigue

- Elastic-Plastic stress tensors calculated from the elastic ones with Neuber rule or Equivalent Strain Energy Density (Glinka)
- Material Memory and Sequence effects captured

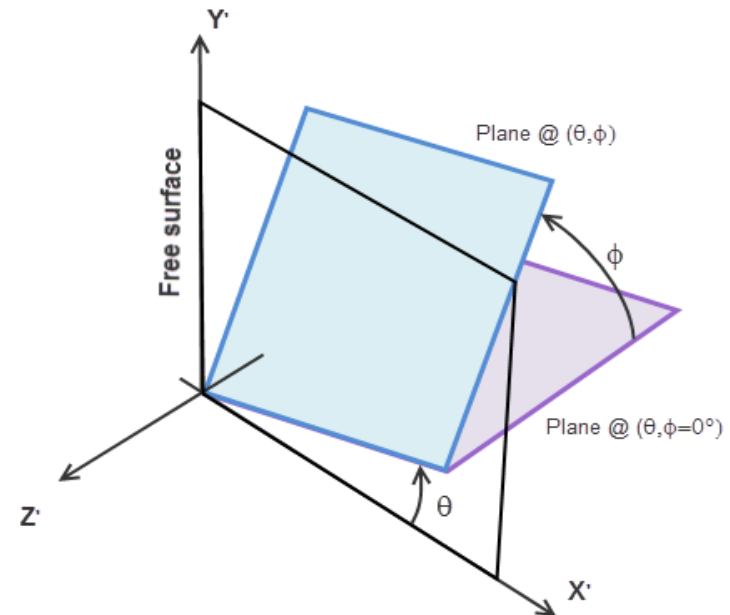


- Fatigue Parameters

- Smith-Watson-Topper, Morrow's, Manson-Halford

LIFING

- Strain Based Fatigue
 - Multiaxial Fatigue:
 - Dowling and Hoffmann-Seeger methods can be used in case of multiaxial proportional loadings
 - Uniaxial Reduction with Critical Plane Search in case of multiaxial non-proportional loadings
 - Critical plane approach with:
 - Smith-Watson-Topper
 - Fatemi-Socie
 - Brown-Miller

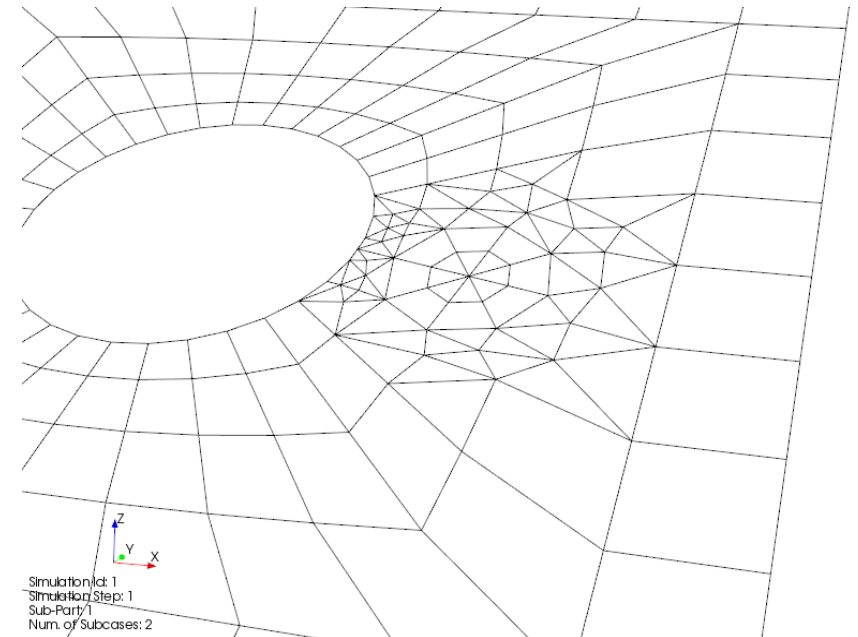
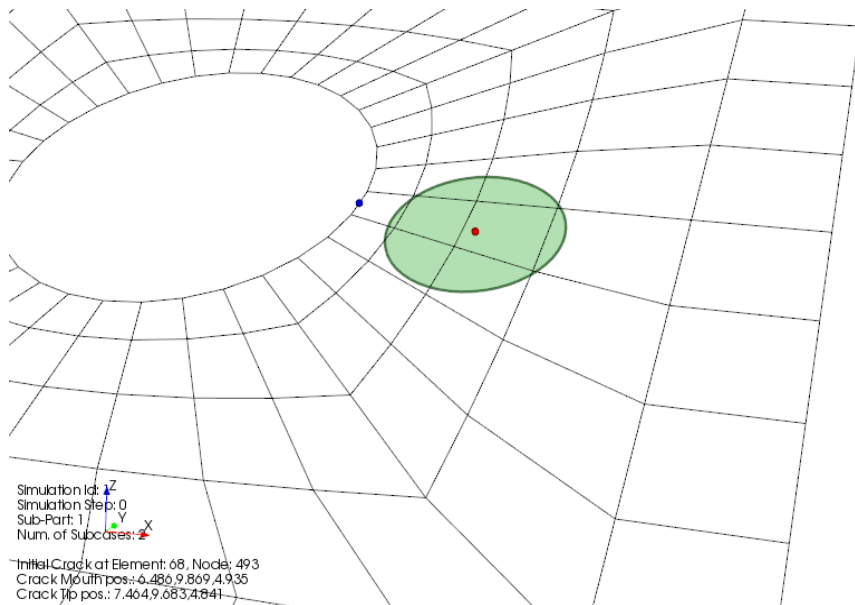


LIFING

- Other features
 - Time History of loads can be provided as
 - Sequence of Load Cases (Fatigue Design style)
 - Linear Combinations of unit Loads (Full Scale Fatigue Test style)
 - Residual stresses can be accounted in the calculation (Lawrence method)
 - Sensitivity analysis can be performed (influence of scaled stresses)
 - Multiaxiality Assessment, element-by-element, can be performed

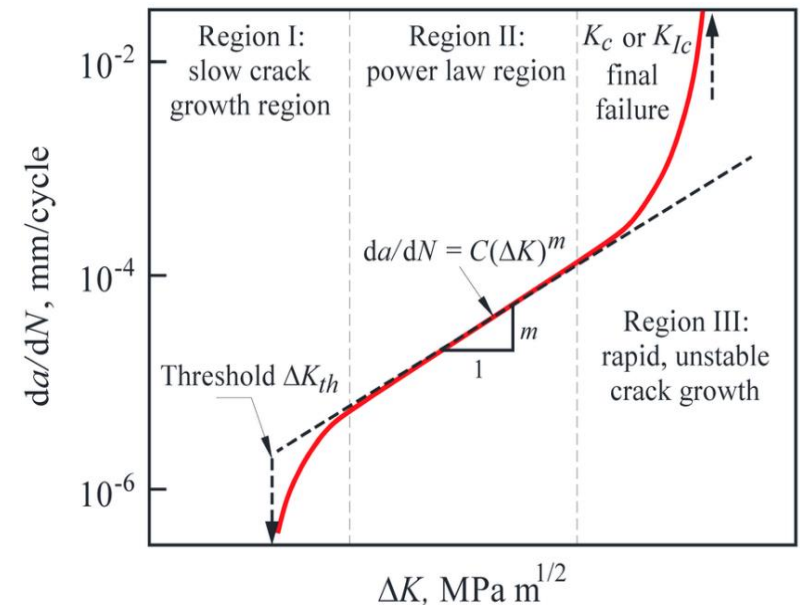
LIFING.GROWTH

- LIFING.Growth is designed to perform crack growth analysis in a thin (shell elements) 2D structure
- The FEM is imported, one or more cracks are introduced at specific locations, the cracks are propagated



LIFING.GROWTH

- An internal mesher is in charge of rebuilding the FEM with the crack discontinuities
- An internal solver is in charge of calculating stress and deformations at each crack propagation step
- The Stress Intensity Factors are calculated step-by-step with J-Integral or displacement correlation
- Crack growth life curve is calculated
 - NASGRO Forman equation solver
 - Generalized Willemberg Crack Closure model implemented
 - Crack Growth material database included (and customizable)



LIFING.HISTORY

- This module has the following functions
 - Modify sequence files (scaling, offsetting, modulating, ...)
 - Filter sequence files (non-turning points, dead-band, truncation delta, clipping)
 - Range-Pair cycle counting
 - Exceedence charts and histograms plotting

