Ansys nCode DesignLife

CAE事業部 李易軒 (Denzel)

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Ansys

內容大綱

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- 內容大綱：

1. Ansys nCode Designlife:方案介紹與疲勞理論說明
2. ANSYS Mechanical UI 操作介面介紹
3. Ansys nCode 獨立介面介紹

- 3.1 應力疲勞分析
- 3.2 載荷事件 (Loading Event) 規劃和累積疲勞損傷
- 3.3 振動疲勞分析

4. Fatigue tool vs. nCode Design Life

nCode DesignLife 產品新方案

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ANSYS 2022
nCode DesignLife 模組介紹

Ansys nCode *DesignLife Pro*	Limited Stress-Life and Strain-Life Limited Load Handling Accessible via only Mechanical UI
Ansys nCode *DesignLife Premium*	Full Stress-Life and Strain-Life –Design Life UI Virtual Strain Gauge & Sensor - Material & Vibration Manager - FE Display Custom Analysis – Signal Processing – Crack Growth Safety Factor – Dang Van – Strain Gauge Positioning
Ansys nCode *DesignLife Enterprise*	Seam Weld – Spot Weld - Vibration Fatigue – Thermo-Mechanical Fatigue – Adhesive Bond

Increasing capability

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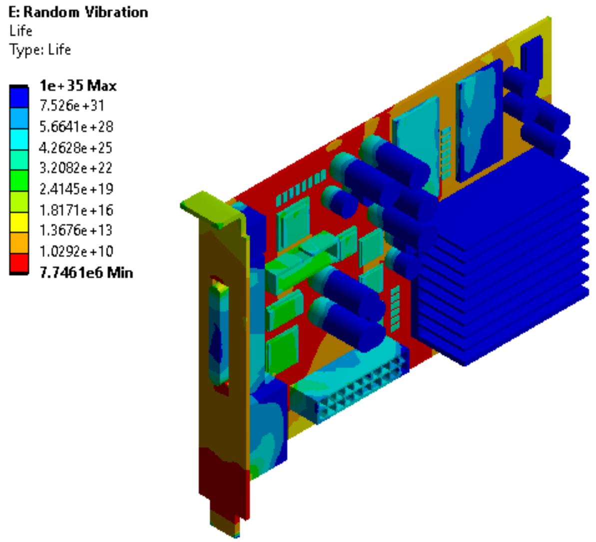
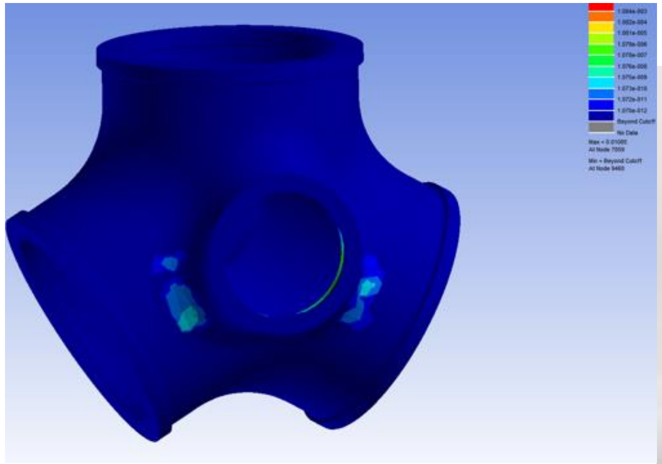
哪種產業需應用疲勞分析

應用產業:

- 車用產品業: 馬達、輪胎、車架疲勞分析
- 電子產品業: 高溫疲勞、隨機振動疲勞、可靠度分析
- 離岸風機業: 輪鼓、夾套焊接處疲勞





何謂疲勞?

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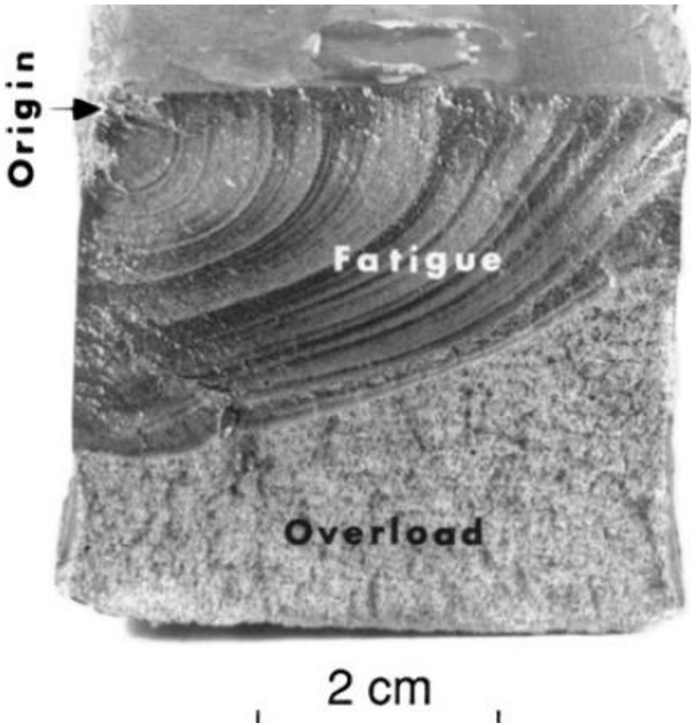
- 用來產生裂紋增長的過程
- **重複施加載重與卸載載重造成結構物破壞之現象**
    - ➢ 分析疲勞方法分成三種
- Stress-life (*SN*) method
    - ➢ 適用於高週疲勞 (1萬次以上)，延性材料
    - ➢ 應力震幅低於降伏點
- Strain-life (*EN*) method
    - ➢ 適用於高週疲勞 ，低週疲勞
    - ➢ 應變震幅為塑性應變
- Frequensy-based method
    - ➢ 隨機震動，簡諧運動



疲勞分析流程

定義材料
*S-N*曲線
包含不同平均應力的*S-N*

應力分析 (包含非線性接觸)
Static structure, Random vibration, Harmonic response

SN life
(高週疲勞)

EN life
(低週疲勞)

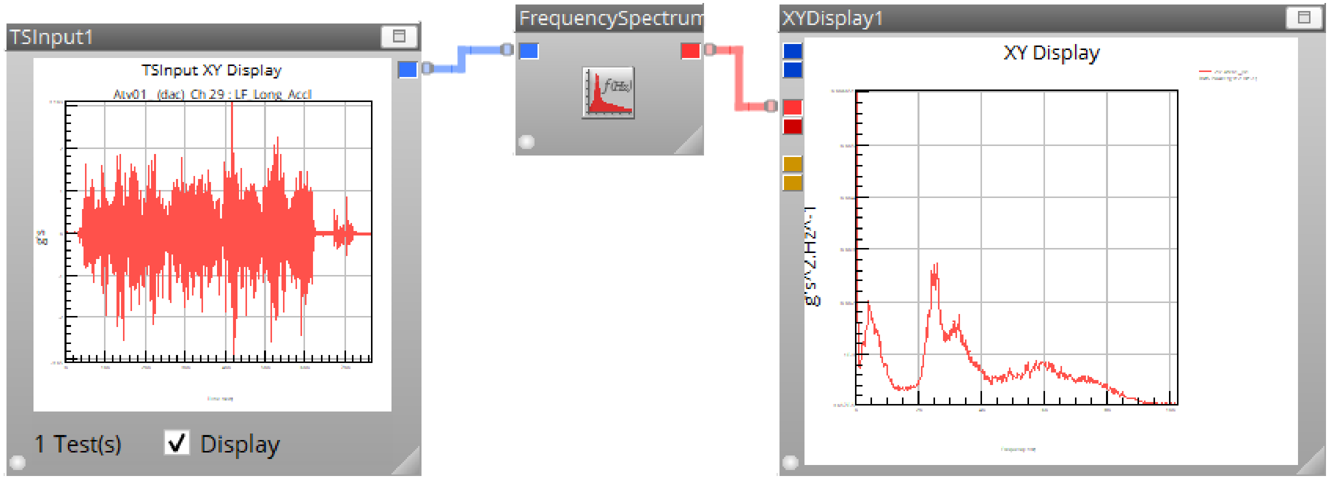
決定mean stress 應力修正方法
決定R-ratio，或者運用不規則波型，進行疲勞評估

後處理結果
壽命、損傷率、安全係數 etc.

疲勞分析的Input and Output

Input

1. 應力結果 => 應力分析 (ANSYS, ABAQUS, NASTRAN)
2. 疲勞曲線圖 => S-N 曲線 (應力疲勞曲線)、E-N 曲線(應變疲勞曲線)
3. 載荷的形式
   - Constant
   - Time Series
   - PSD
   - Temperature



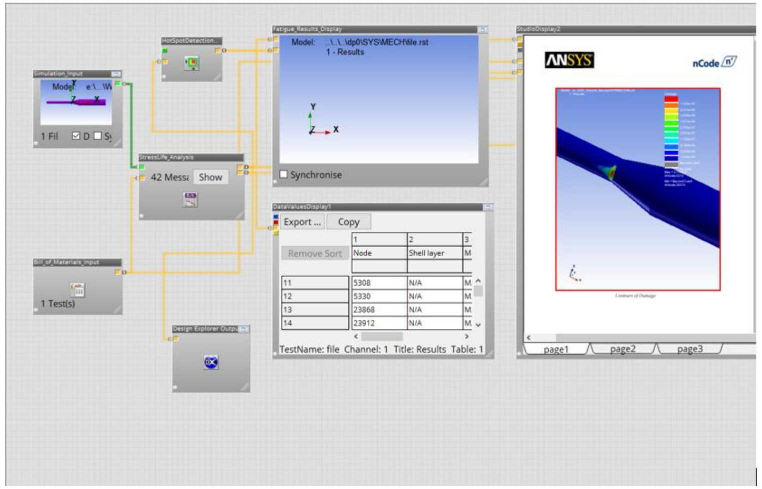
Output

1. 損傷
2. 壽命
3. 熱點分析

Ansys疲勞分析

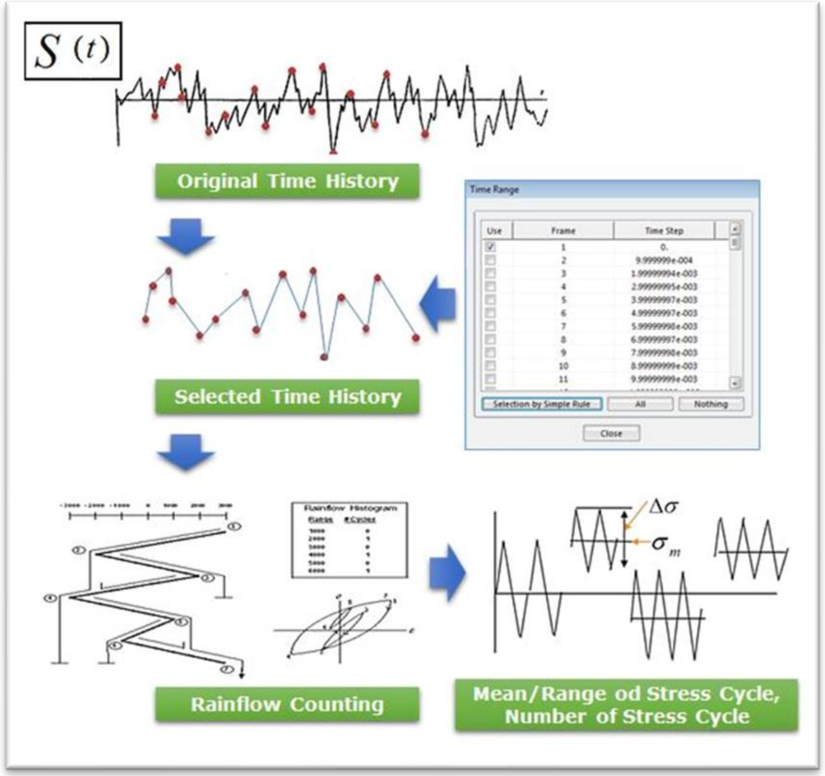
- Ansys Mechanical Fatigue tool
  - ➢ Mechanical裡的工具
  - ➢ 用來評估疲勞壽命的分析工具
  - ➢ 適用於*SN*, *EN*, Frequency-based 之方法
  - ➢ 支援兩軸疲勞負載施加
  - ➢ 只能適用於Static structure, Transient structure, Random vibration, Harmonic response以上的模組。

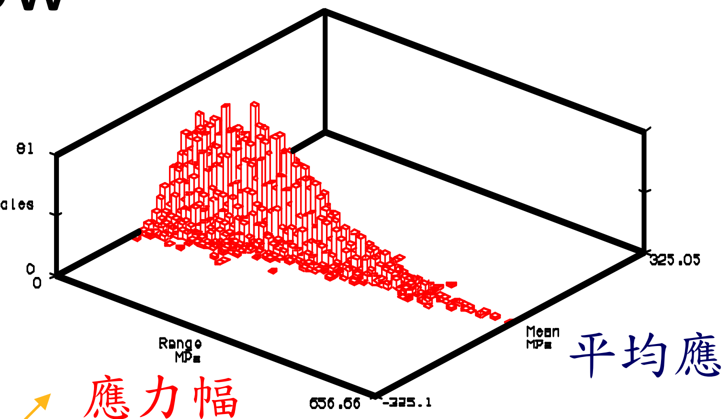
- Ansys nCode Design Life
  - ➢ 與 Ansys Workbench進行介面整合
  - ➢ 豐富的材料庫
  - ➢ 事件疲勞的損傷累積
  - ➢ 支援兩軸以上疲勞負載施加
  - ➢ 高溫疲勞，焊接疲勞，振動疲勞...etc.

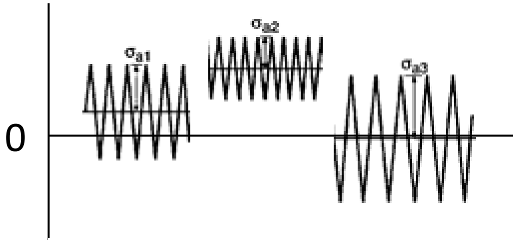


疲勞常見分析方法-Rainflow

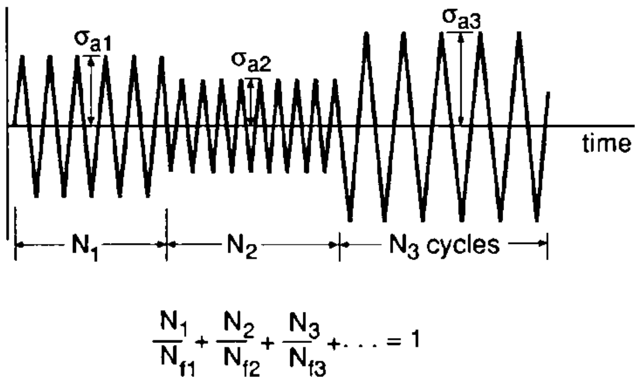
- 雨流計數法_統計分析







平均應力修正法



FKM Guideline
Goodman & Goodman Tension Only
Gerber & Gerber Tension Only
Soderberg
Walker
ASME Elliptical
Morrow
Smith Watson Topper

Ncode支援左側修正Mean Stress的方法

Ansys nCode

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nCode

1. 減少對打樣測試的依賴，節約設計和時間成本
2. 在做物理試驗前，先進行快速的模擬分析
3. 降低產品的失效以減少用戶端報修
4. 為優化方案提供最佳選擇方案
5. 標準化分析流程，以提高一致性品質
6. 模擬分析與物理試驗結果直接關聯

nCode DesignLife 是全球領先的**疲勞分析**軟體. 系統在產品原型開發完成之前，進行從”有限元分析”到 耐久性和認證分析的**疲勞壽命預測**.

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New Product : Ansys nCode DesignLife - PRO

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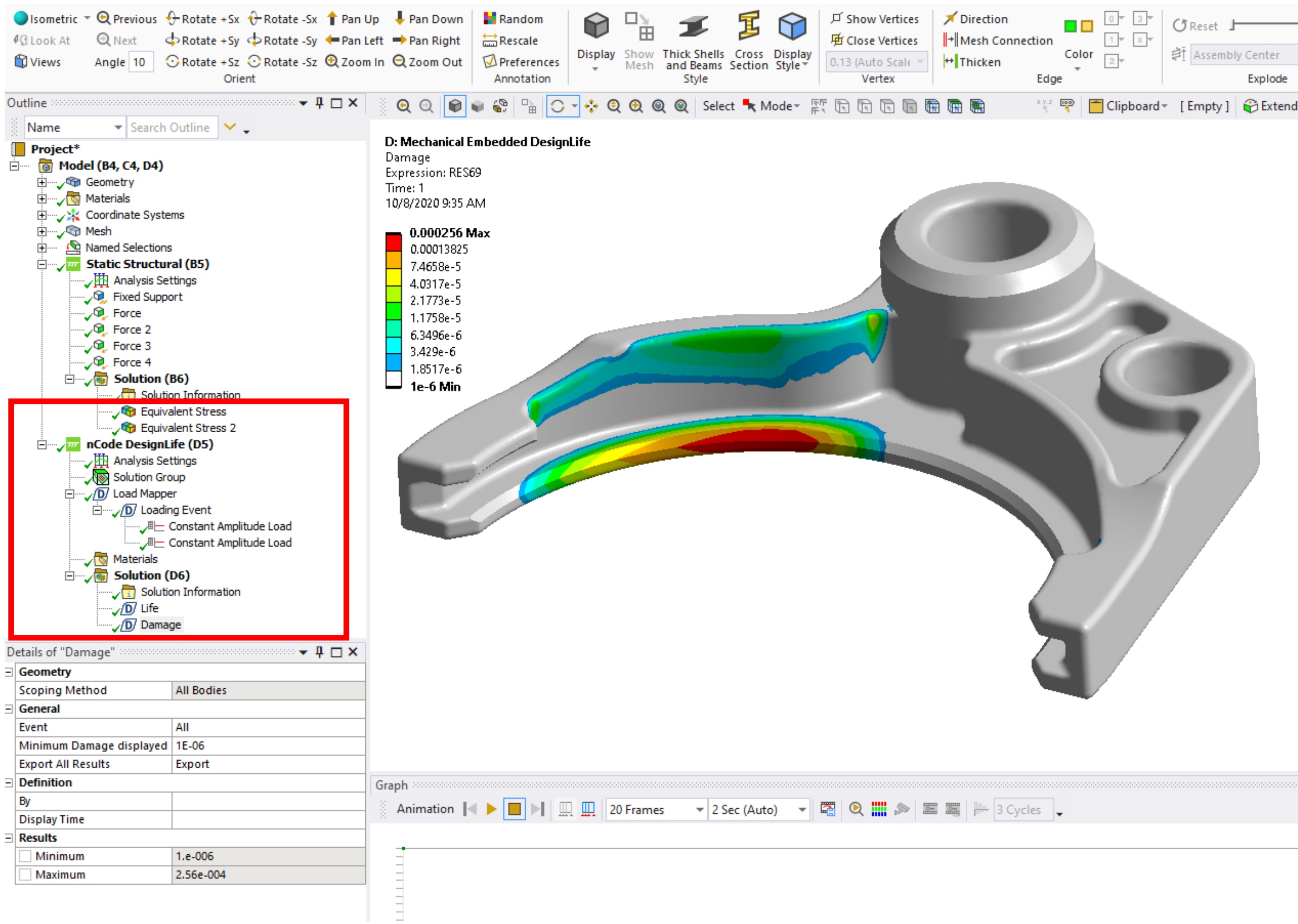
- **Analysis-Domain**
  - ➢ Time Based
  - ➢ Frequency Based
- **Solver**
  - ➢ SN
  - ➢ EN
  - ➢ Seam Weld
- **Loading Event – Quick and Easy**
  - ➢ Constant Amplitude, Time Step, Time Series
  - ➢ Import/Export Loading Event
  - ➢ PSD
- **Solution Group**
  - ➢ Utilize existing name selection or select geometry on which user wants to review results
- **Material**
  - ➢ Material library accessible in Mechanical UI
- **nCode Solver**
  - ➢ All in background
  - ➢ Monitor solution via output window/file
- **Post Processing**
  - ➢ Mechanical way synced with nCode



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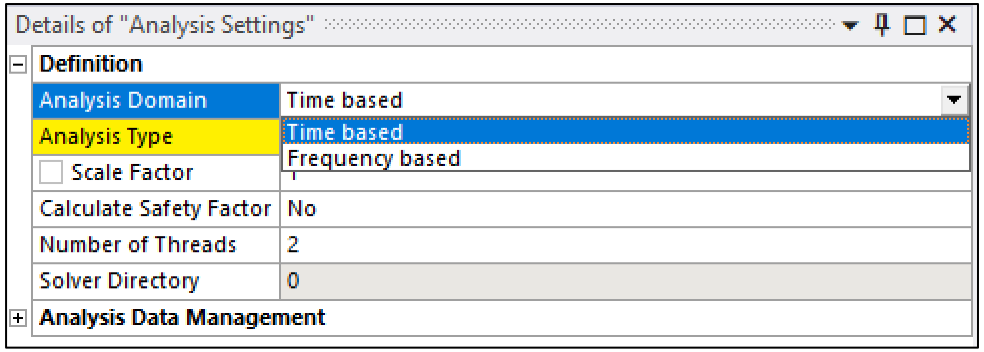

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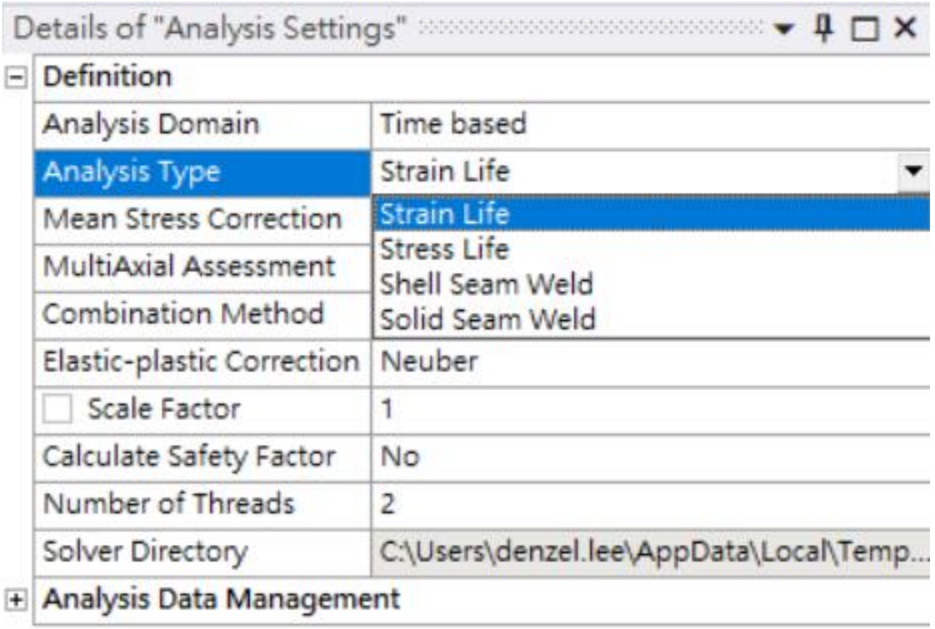

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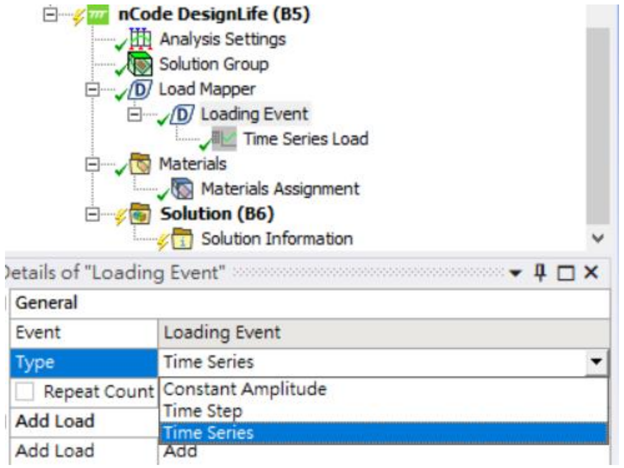

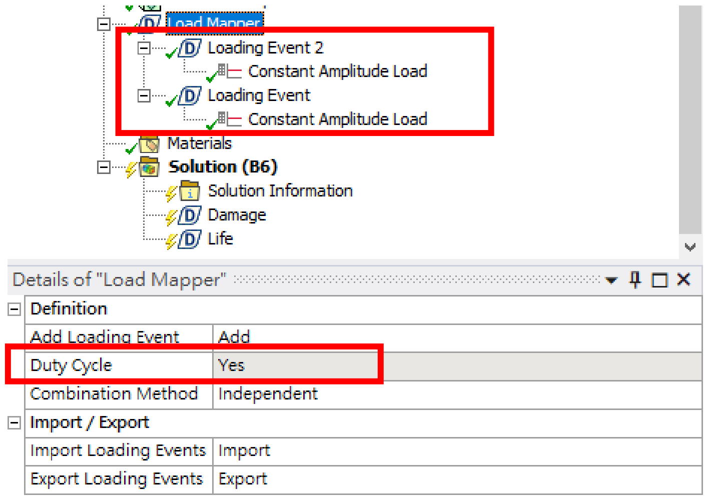

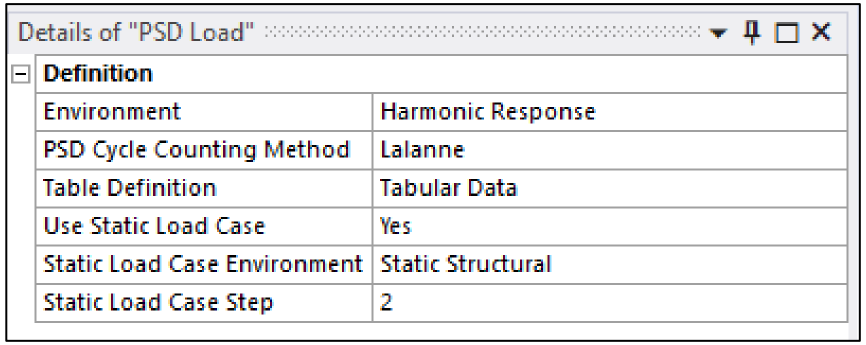

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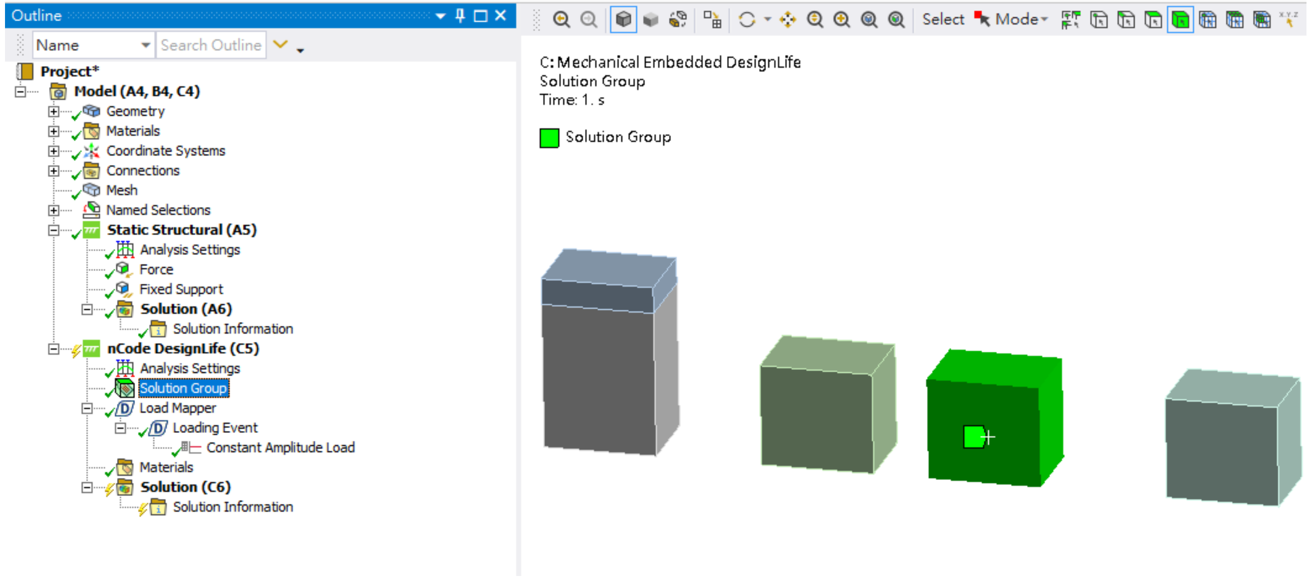

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Materials
Materials Assignment
Solution (B6)

Details of "Materials Assignment"

General	
Based on Material	6061-T6
Fatigue Type	Stress
S-N Curve	Tabular Data
Number of S-N Curves	3
S-N Curve Definition	R-Ratio
R-Ratio - Curve 1	-1
R-Ratio - Curve 2	-0.5
S-N Curve 2	Tabular Data
R-Ratio - Curve 3	0
S-N Curve 3	Tabular Data
Stress Offset	0 MPa
Scale Factor	1
Young's Modulus	68947.57 MPa
Poisson's Ratio	0.33
Tensile Ultimate Strength	310.264065 MPa
nCode Material Type	Aluminum
Import S-N Curve	
Import S-N Curve	Import
Import S-N Curve Number	1

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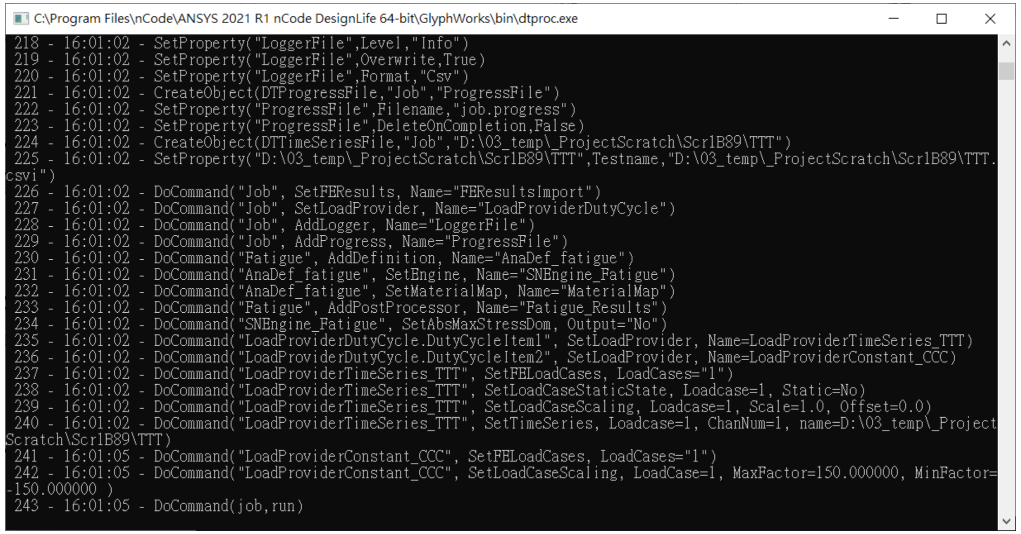

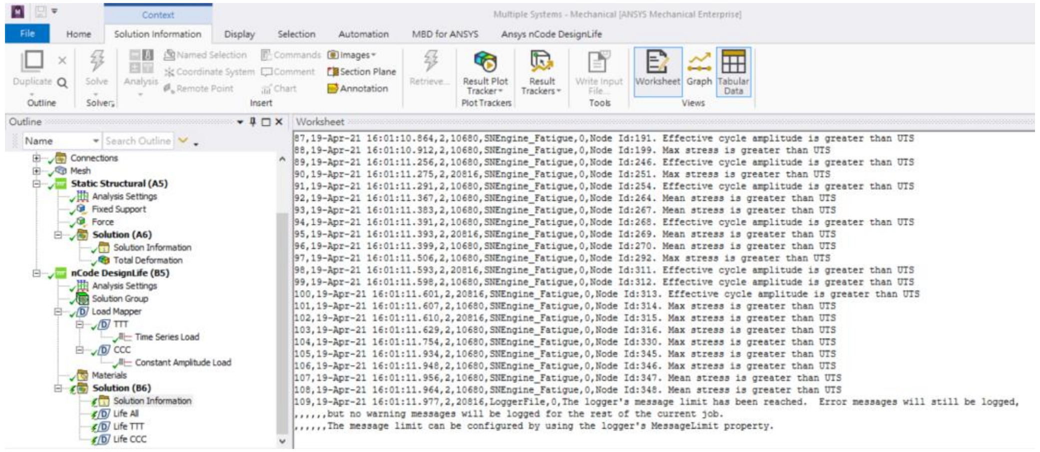

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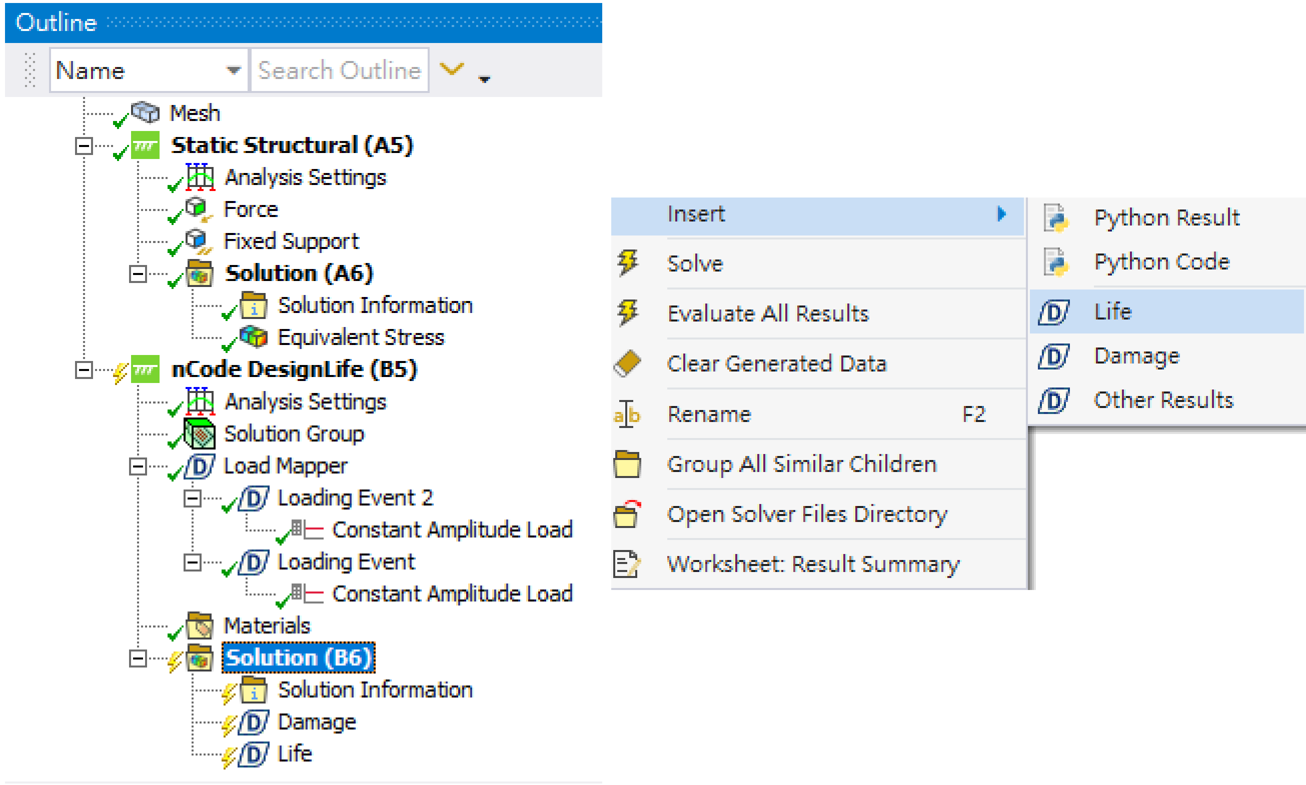

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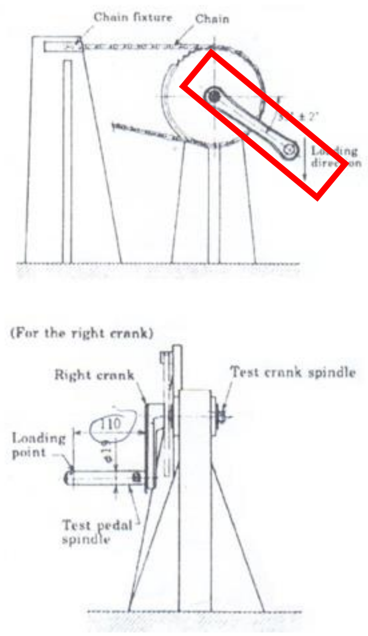
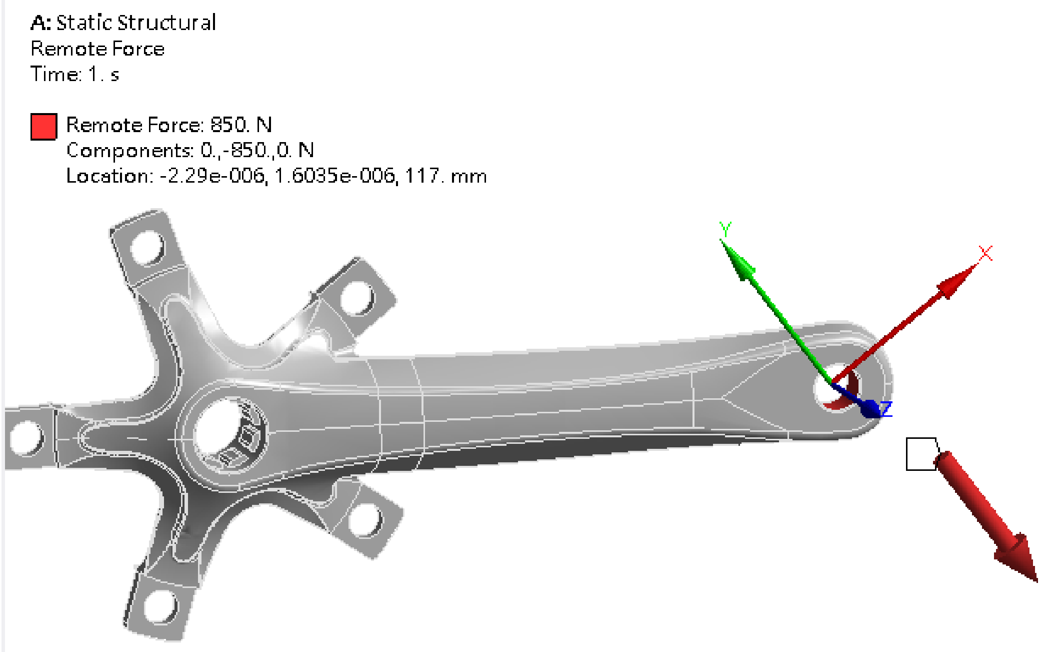
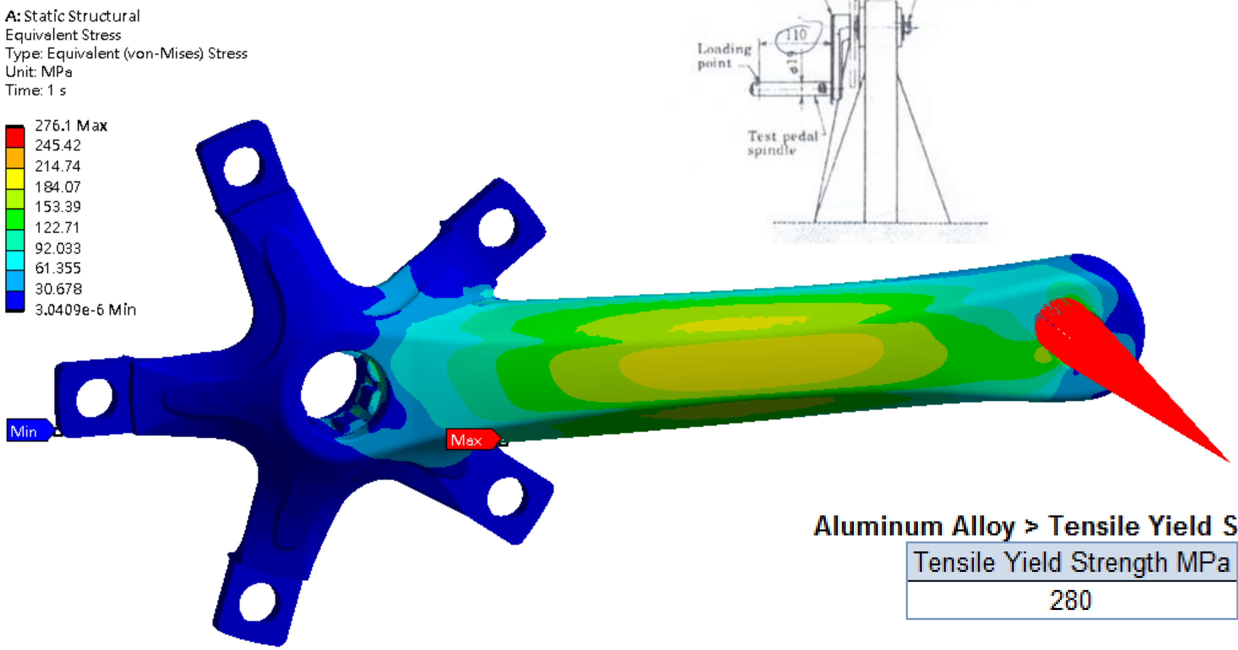
案例分析-問題描述

- 曲柄疲勞分析
  - 描述:施加850 N，測試100000次後，曲柄需無任何破損及組件鬆動
  - 材料：鋁合金







Aluminum Alloy > Tensile Yield Strength

Tensile Yield Strength MPa
280

案例分析-Input for fatigue

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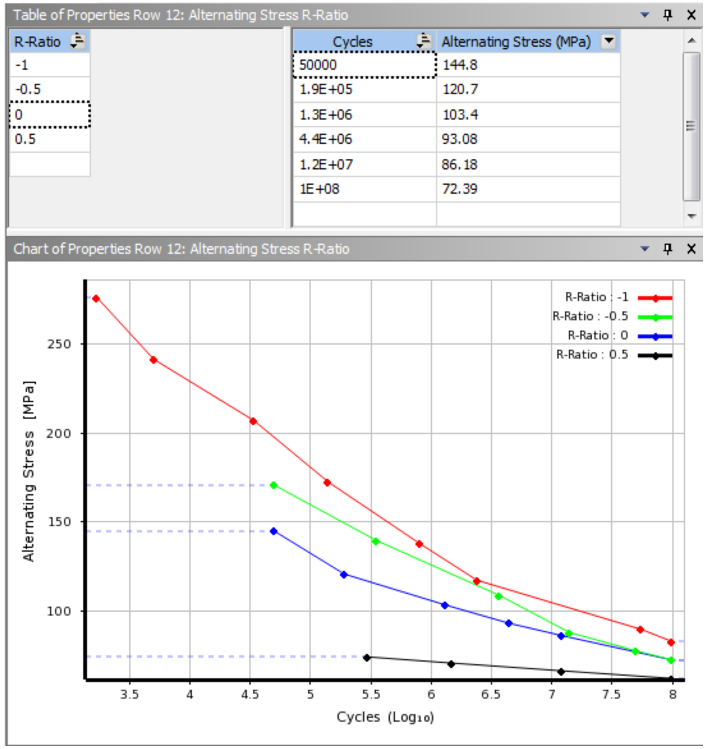
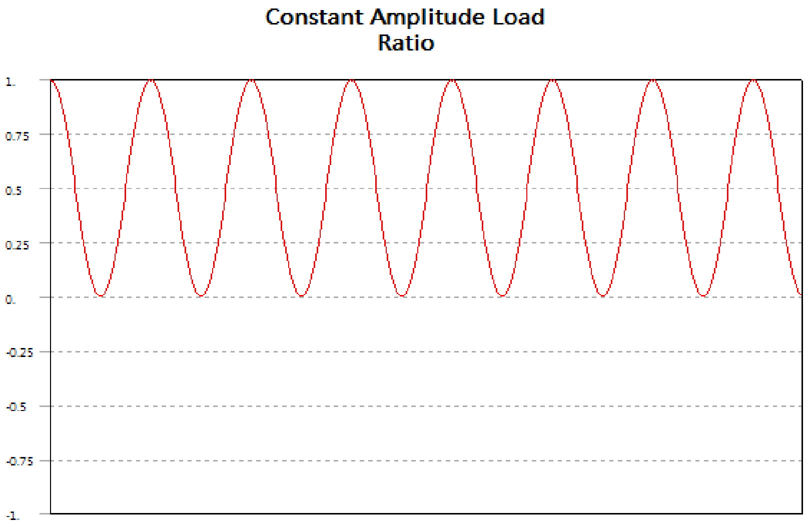
- 鋁合金應力(S-N)曲線圖 (Muti-R ratio)



R-Ratio
-1
-0.5
0
0.5

Cycles	Alternating Stress (MPa)
50000	144.8
1.9E+05	120.7
1.3E+06	103.4
4.4E+06	93.08
1.2E+07	86.18
1E+08	72.39

- 載荷類型



Mean Stress Correction: Goodmen

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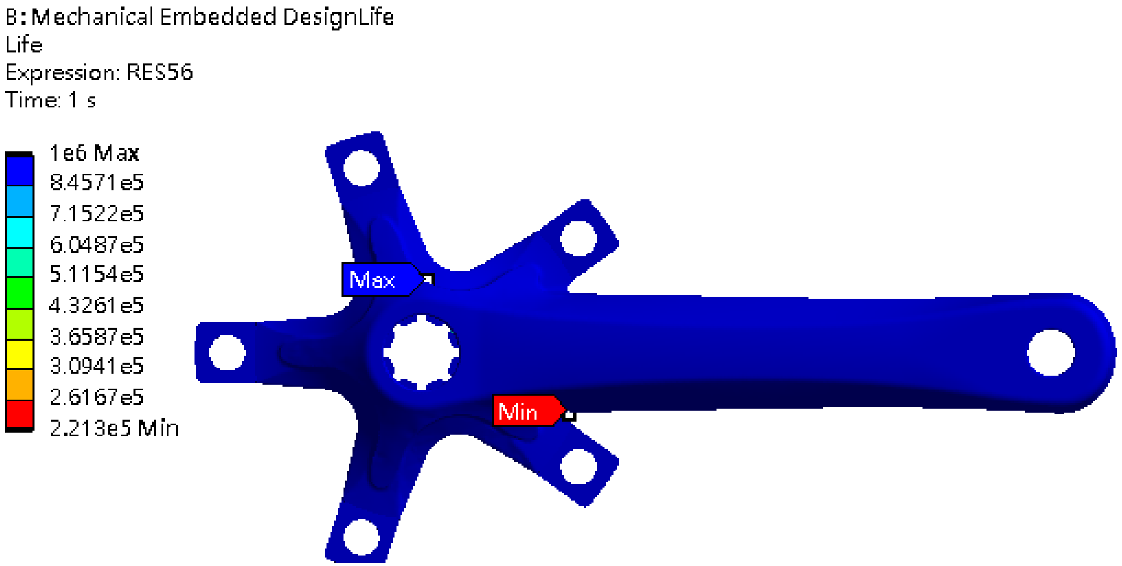
案例分析-Output

- 疲勞壽命分析結果
- 結論：

根據 測試規範，曲柄於此規範下必須能夠承受10萬次的循環
載荷而不能有任何破損，最嚴重的位置可以承受22萬次的壽命，因此符合規範。



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分析流程模板

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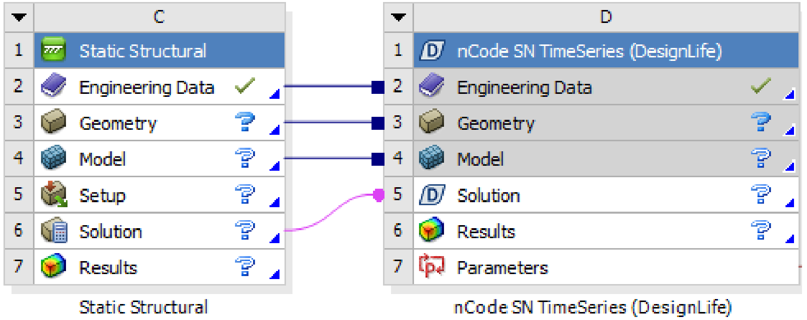
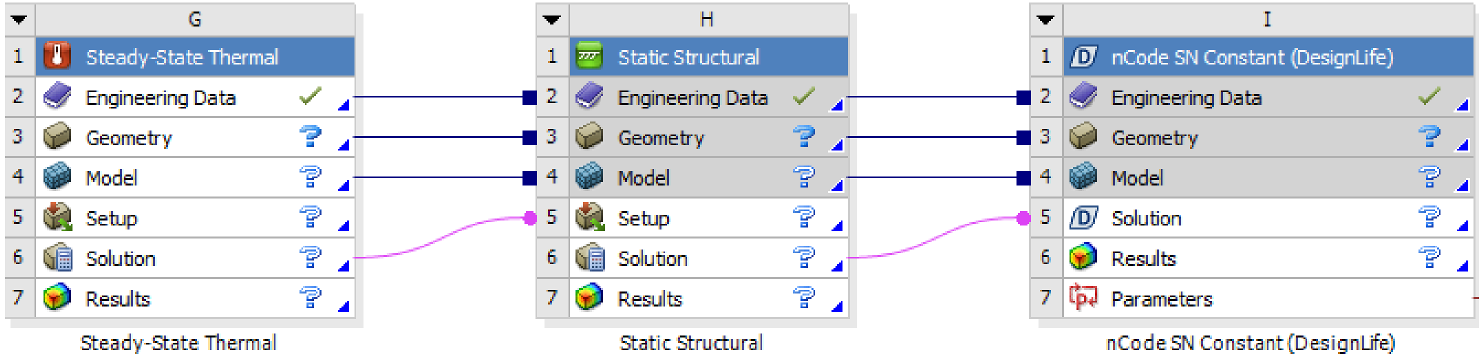
nCode EN Constant (DesignLife)
nCode EN TimeSeries (DesignLife)
nCode SN Constant (DesignLife)
nCode SN TimeSeries (DesignLife)
nCode SN VibrationPSD (DesignLife)
nCode SN VibrationSweptSine (DesignLife)
nCode WeldShellSeam (DesignLife)
nCode WeldSolidSeam (DesignLife)

Static analysis_Linear/Non-linear



Temperature stress analysis_Linear/Non-linear



分析流程模板

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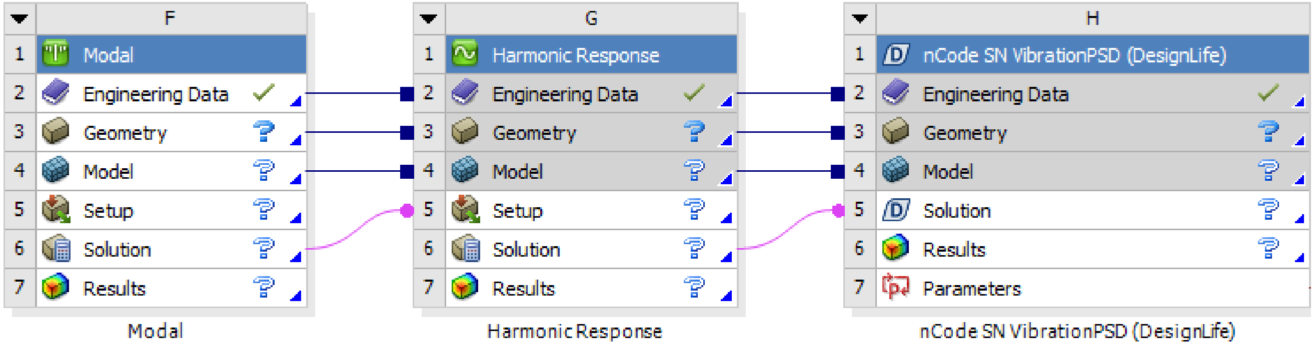
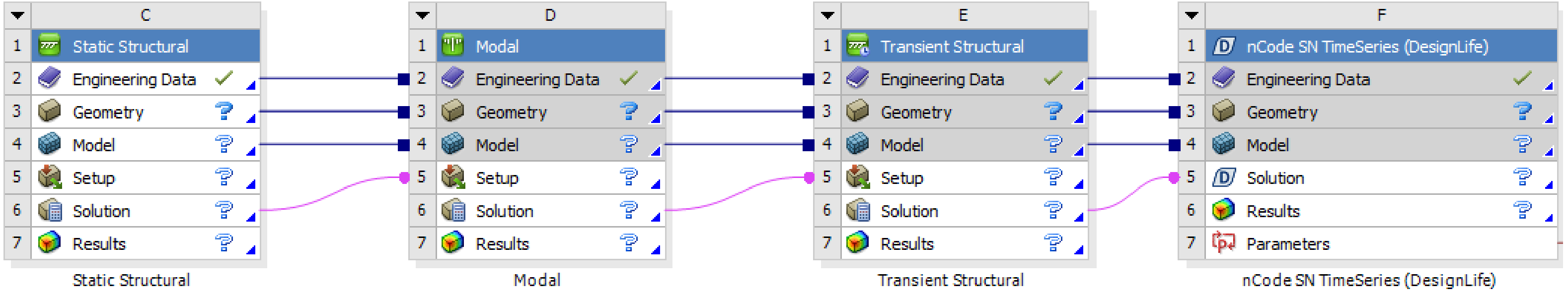
Dynamic analysis_Frequency domain_Linear



Dynamic analysis_Time domain Linear/Non-Linear



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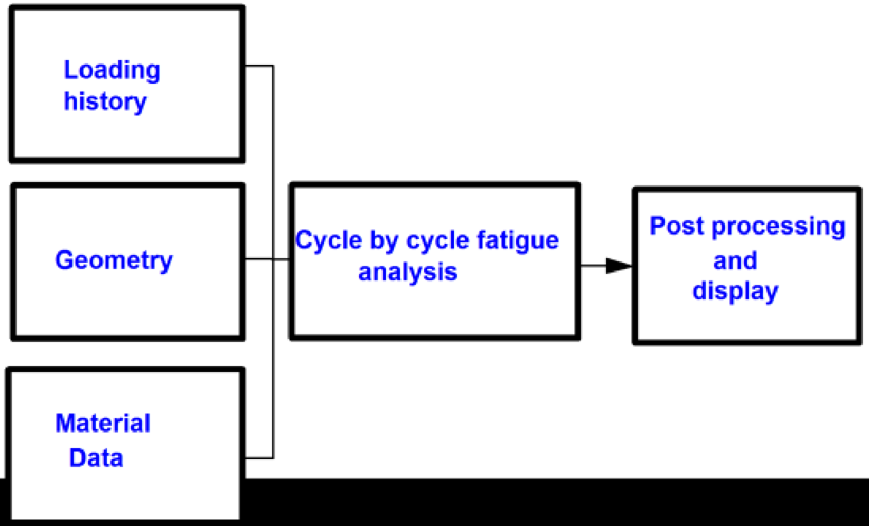
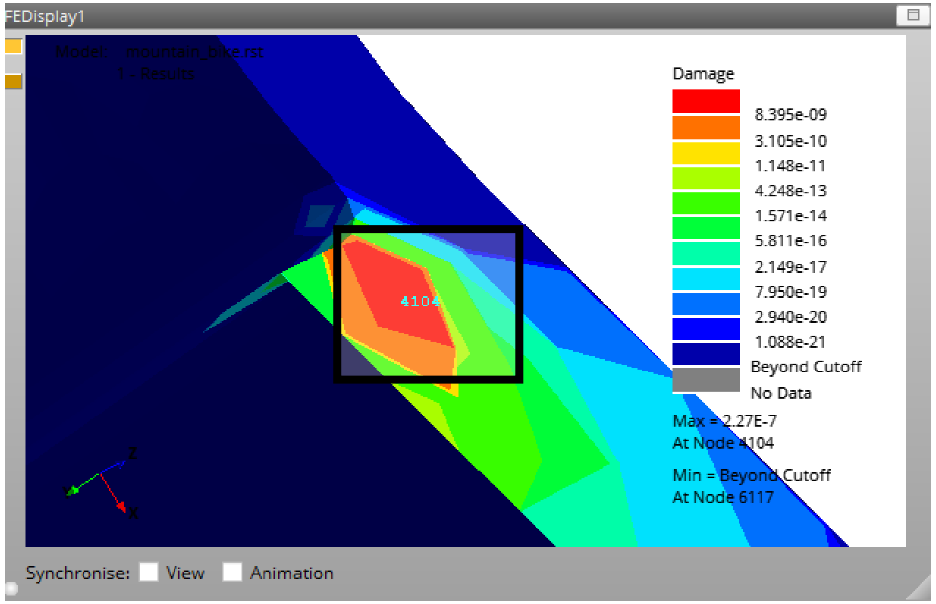
案例分析-問題描述

- 目標:
  - 利用SN曲線計算越野自行車車架在恆定振幅 (0-3 G)下的負載，並且評估其壽命和熱點。
- 步驟
  - 匯入應力結果檔
  - 設定振幅載重
  - 進行疲勞壽命與損傷的後處理
  - 加入熱點偵測，抓出前10個疲勞損傷較高的區域



案例分析- Output

- 找尋特定點的疲勞損傷或是壽命



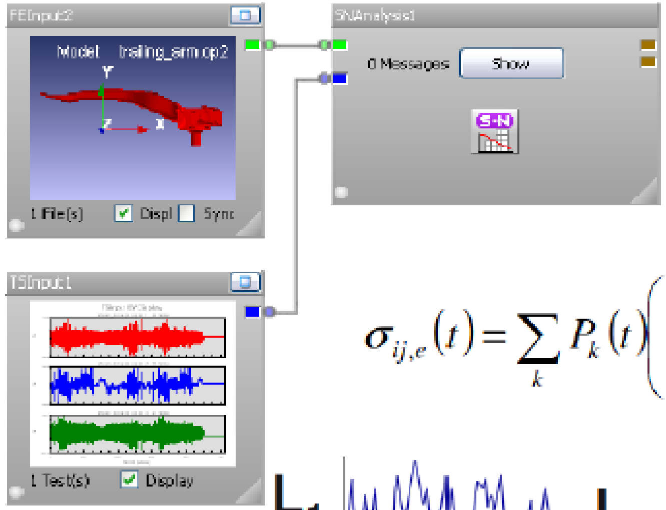
DataValuesDisplay2

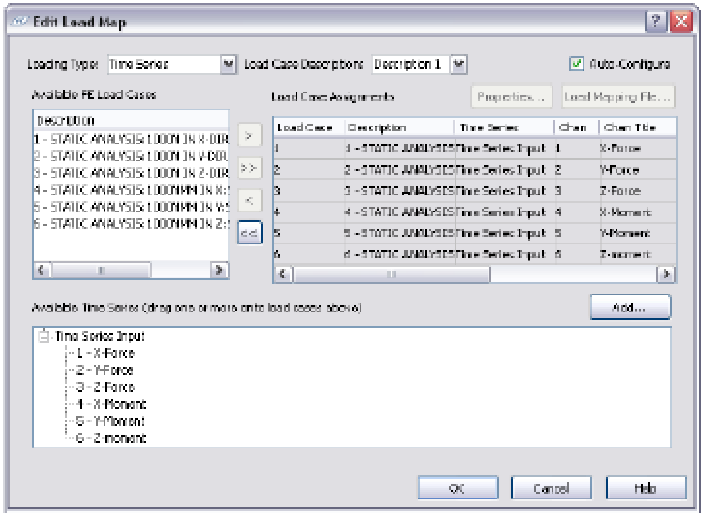
Export ... Copy

Remove Sort	1 Node	2 Shell layer	3 Material Group	4 Property ID	5 Material ID	6 Damage	7 Mean biaxiality	8 Non-proportion	9 Dominant stres degrees	10 Life Repeats
1	4104	Top	All entities	2	4	2.27e-07	0.0242	0	-9.39	4.406e+06
2	4142	Bottom	All entities	2	4	1.399e-07	0.05487	0	28.74	7.147e+06
3	4104	Bottom	All entities	2	4	1.205e-07	0.1362	0	-7.271	8.3e+06
4	4142	Top	All entities	2	4	1.122e-07	0.05214	0	24.81	8.916e+06
5	4105	Top	All entities	2	4	5.469e-08	-0.02344	0	-36.4	1.829e+07
6	4105	Bottom	All entities	2	4	1.056e-08	0.148	0	-36.01	9.469e+07
7	4138	Top	All entities	2	4	6.15e-09	0.1119	0	10.75	1.626e+08
8	77	Bottom	All entities	2	4	5.035e-09	0.7124	0	84.2	1.986e+08
9	92	Bottom	All entities	2	4	4.411e-09	0.4133	0	80.6	2.267e+08

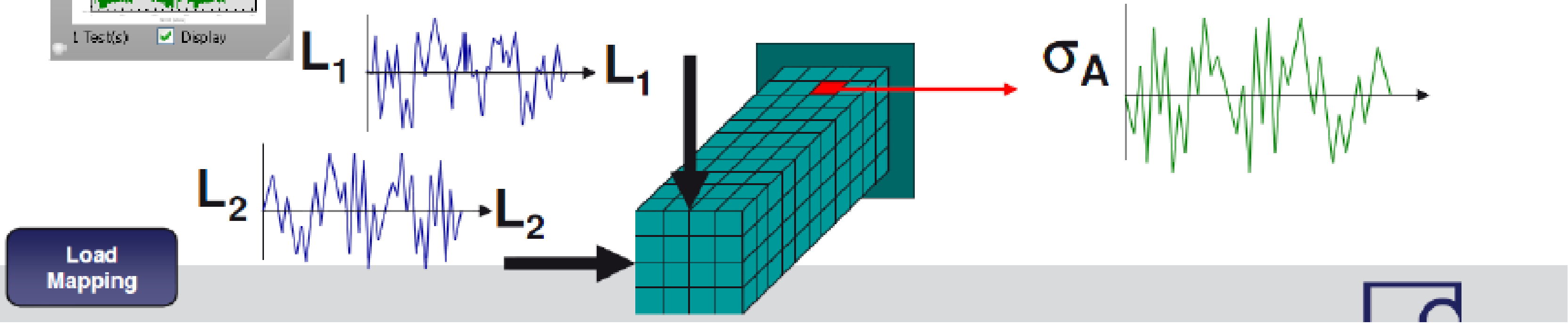
nCode 支援多軸載荷

- Available FE Loadcases can be paired with measured Time Series channels to generate stress or strain histories





$$\sigma_{ij,e}(t)=\sum_{k} P_k(t)\left(\frac{\sigma_{ij,e,k}}{P_{k,fea}}\right)$$

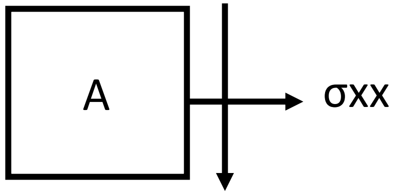


支援不同等效應力的方法。

- **maximum principal stress (脆)**
- **von-Mises stress (延)**
- **maximum shear stress**

支援不同評估多軸的方法。

- **SimpleBiaxiality**
- **Standard**
- **Auto**



內容大綱

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- 3.1 應力疲勞分析
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4. Fatigue tool vs. nCode Design Life

Ansys

Loading Event

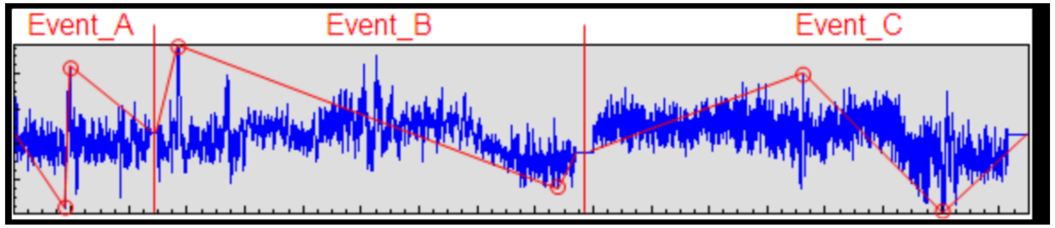
- 分析多個事件並將結果組合的過程，以工作週期或耐用性時間表來表示。
- Event_A.rsp
- Event_B.rsp
- Event_C.rsp

實駕路測 ➔ 收集訊號資料 ➔ 重新產生輸入資料

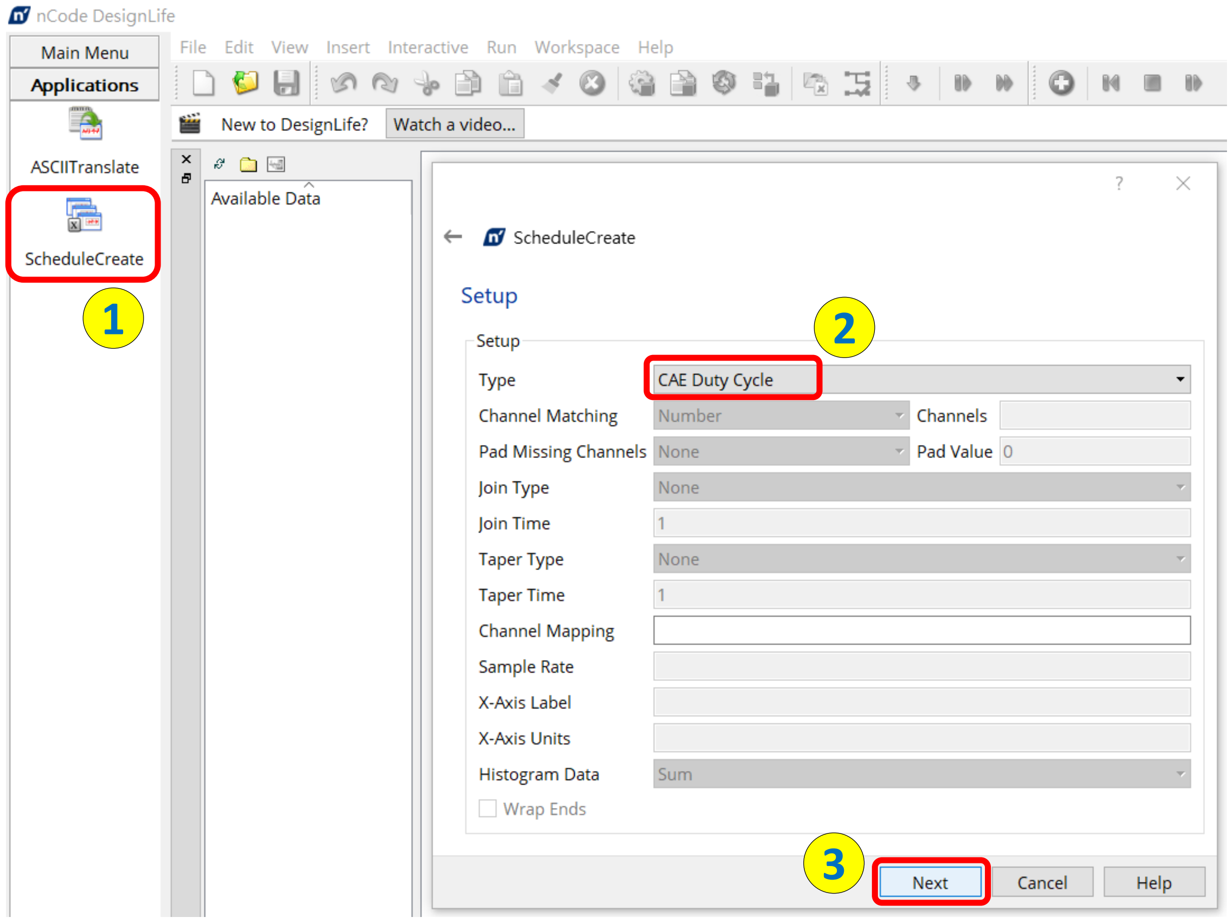
實駕路測

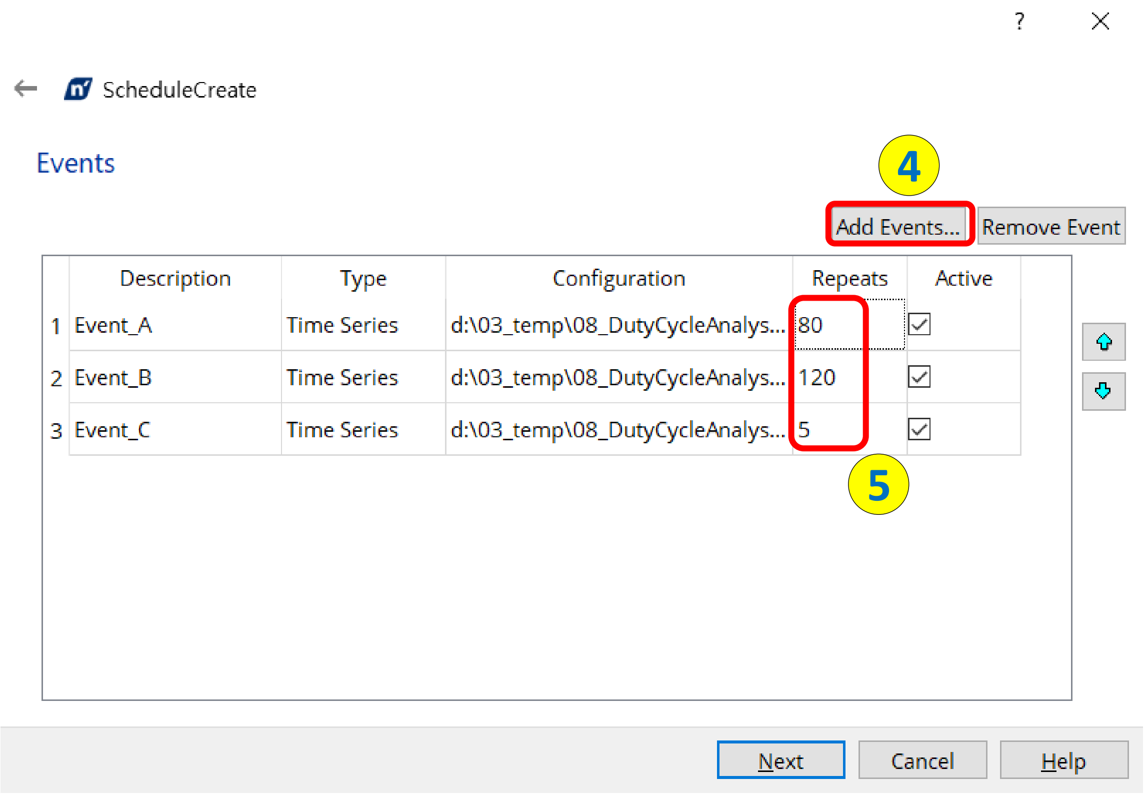
測試台

收集訊號資料



Creating a Loading Event





Result for cycle loading

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	Independent		CombinedFast		CombinedFull	
	Damage	Life	Damage	Life	Damage	Life
Event_A	0.01156	86.48	0.01162	86.09	0.01162	86.06
Event_B	0.02557	39.1	0.0249	40.15	0.02566	38.97
Event_C	0.005377	186	0.005351	186.9	0.005349	187
ALL	0.04251	23.52	0.04187	23.88	0.04263	23.46

Ncode可以支援當機器經歷了Event A、Event B, 和Event C之後所累積的損傷。上圖呈現使用不同的方法，用來計算事件與事件之間的疲勞損傷。

Ansys

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Base Excitation Acceleration Loading

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- 簡諧分析

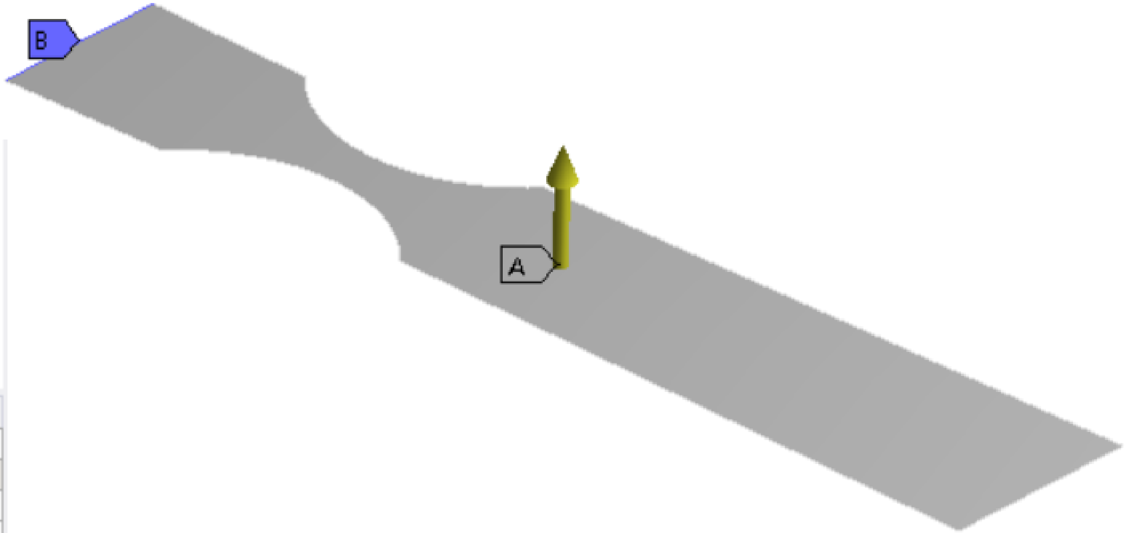
- Harmonic Response (A5)
  - Modal (None)
  - Analysis Settings
  - Acceleration
  - Fixed Support
  - Solution (A6)
    - Solution Information
    - Equivalent Stress

Details of "Analysis Settings"

Step Controls	
Multiple RPMs	No
Options	
Frequency Spacing	Linear
Range Minimum	10. Hz
Range Maximum	1000. Hz
Cluster Number	4
User Defined Frequencies	Off
Solution Method	Mode Superposition
Include Residual Vector	No
Cluster Results	Yes
Modal Frequency Range	Program Controlled

A: Model, Harmonic Response
Harmonic Response
Frequency: 10. Hz
2021/1/15 下午 04:13

A Acceleration: 9810. mm/s²
B Fixed Support



- Harmonic Response (A5)
  - Modal (None)
  - Analysis Settings
  - Acceleration
  - Fixed Support
  - Solution (A6)
    - Solution Information
    - Equivalent Stress

Details of "Acceleration"

Scope	
Geometry	All Bodies
Definition	
Base Excitation	No
Define By	Components
Coordinate System	Global Coordinate System
X Component	0. mm/s²
Y Component	0. mm/s²
Z Component	9810. mm/s²
Suppressed	No

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Adding DesignLife System for Vibration Fatigue

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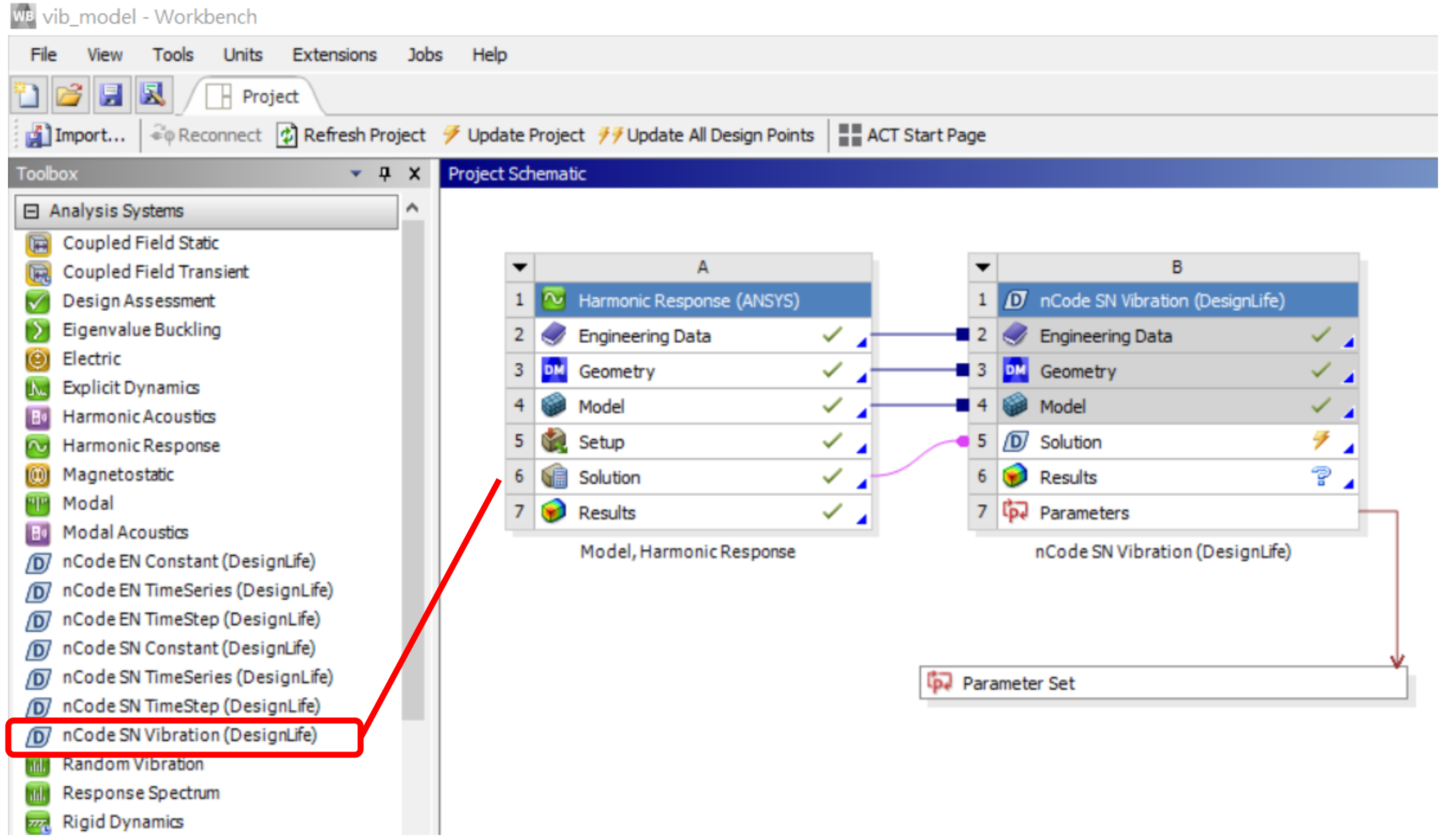
- 振動疲勞分析



Defining the Inputs and Analysis

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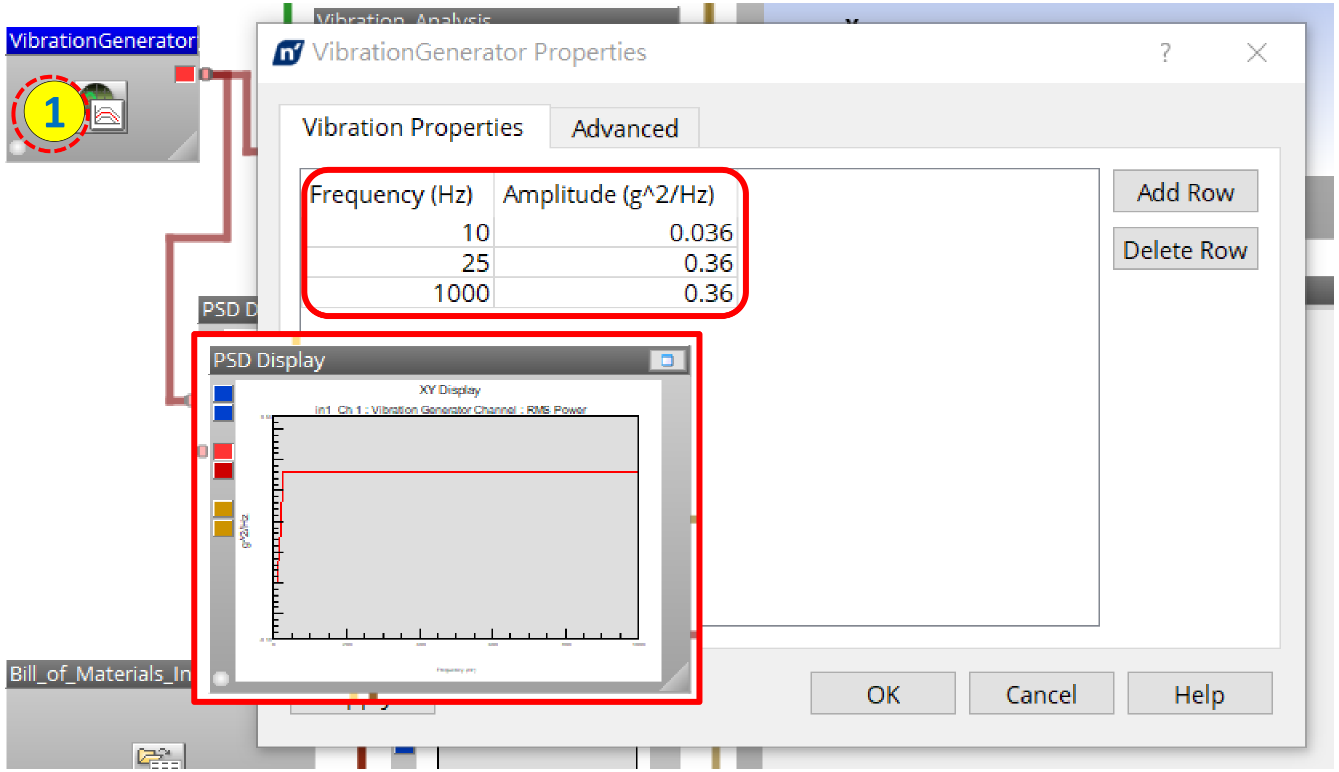
• 滑鼠右鍵，定義輸入



Load Mapping

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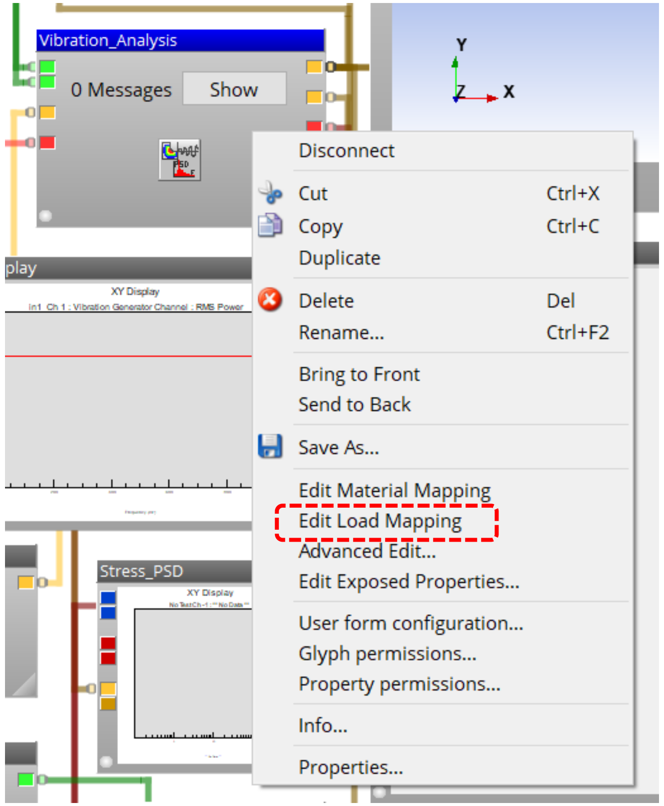
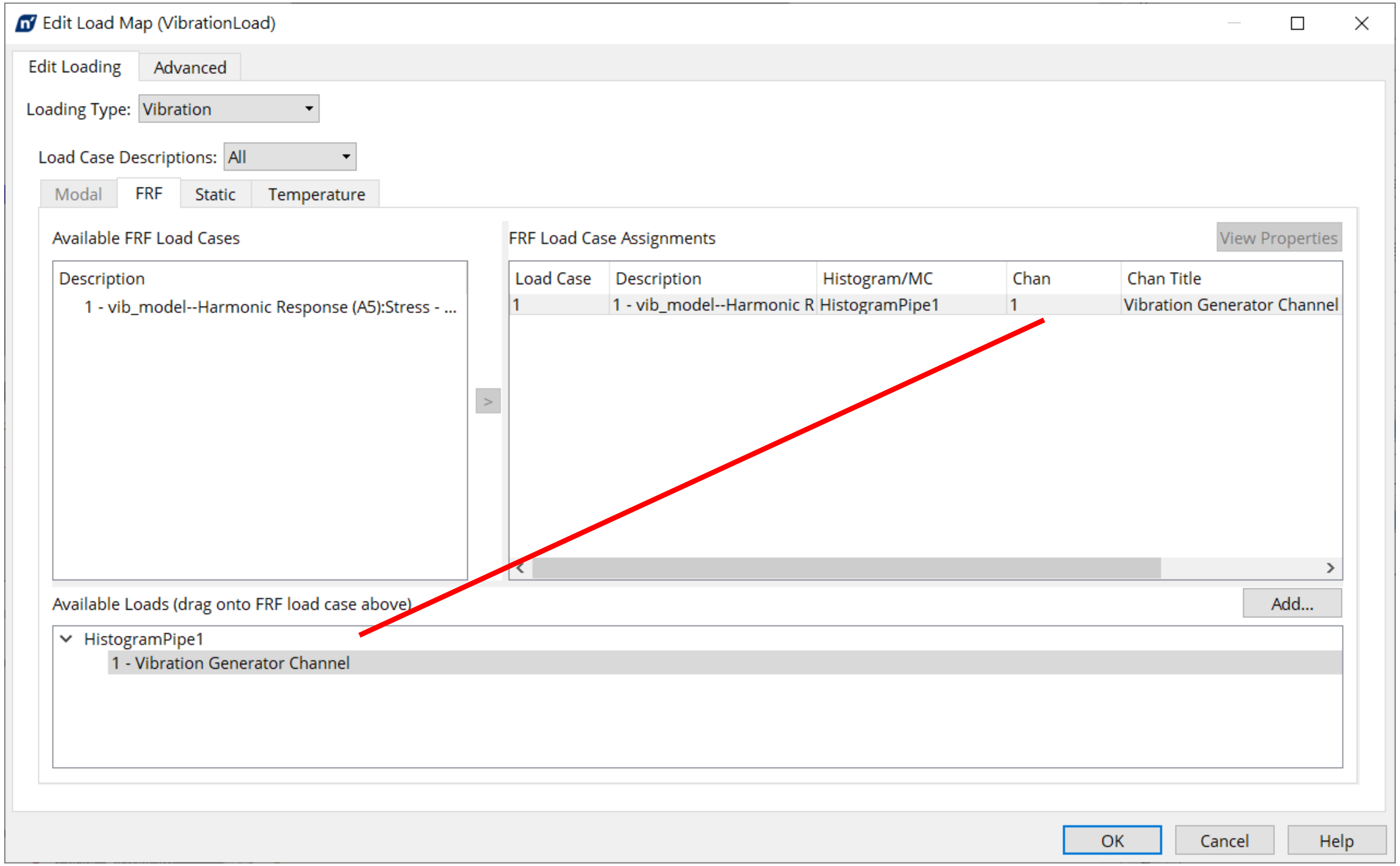
- Loading : Vibration





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Solve and Post-processing

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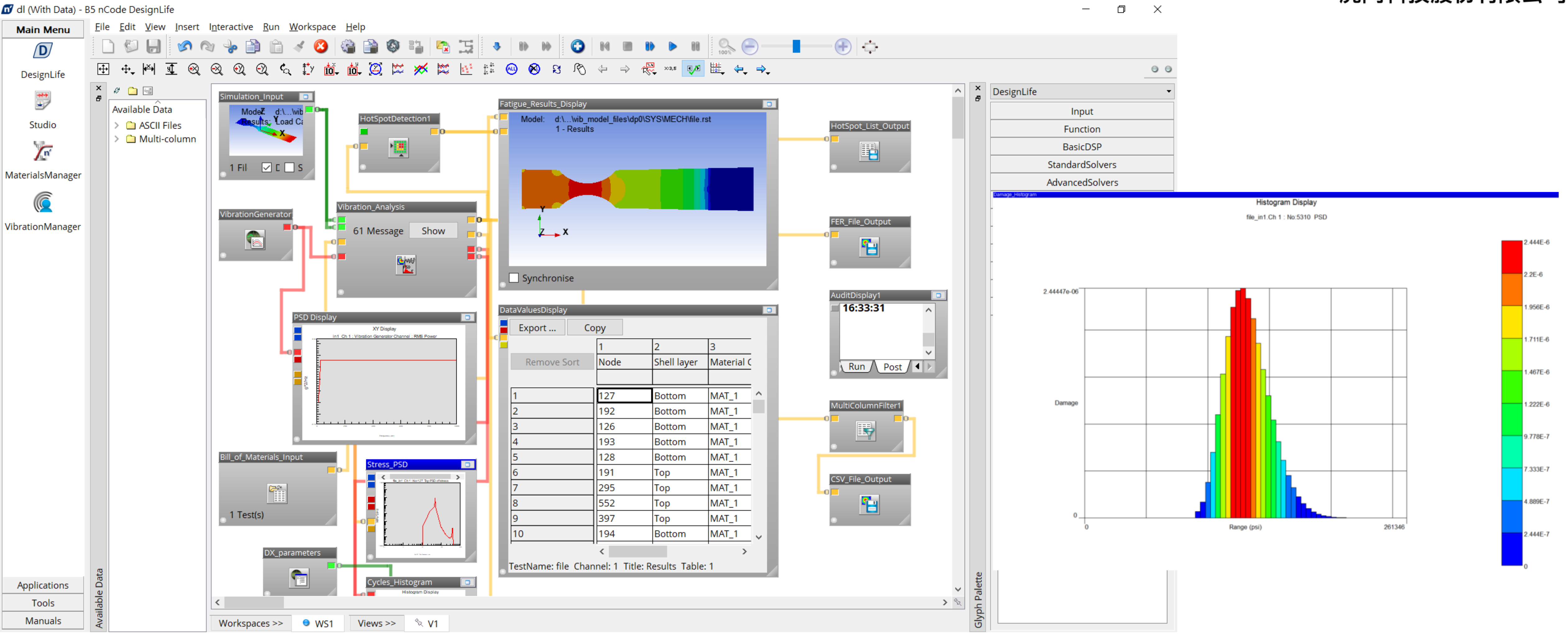

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4. Fatigue tool vs. nCode Design Life

Fatigue tool V.S Ncode design life

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疲勞負載以及功能	Ansys fatigue tool	Ncode
靜態SN,EN	√	√
線性動態疲勞	√	√
雙軸疲勞	√	√
多軸疲勞		√
非比例時域加載		√
平均應力/應變校正	√	√
事件累積損傷		√
焊縫疲勞		√
裂縫成長		√
溫度疲勞		√
缺口效應		√
熱點偵測		√

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謝謝!

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