Ease the Stress

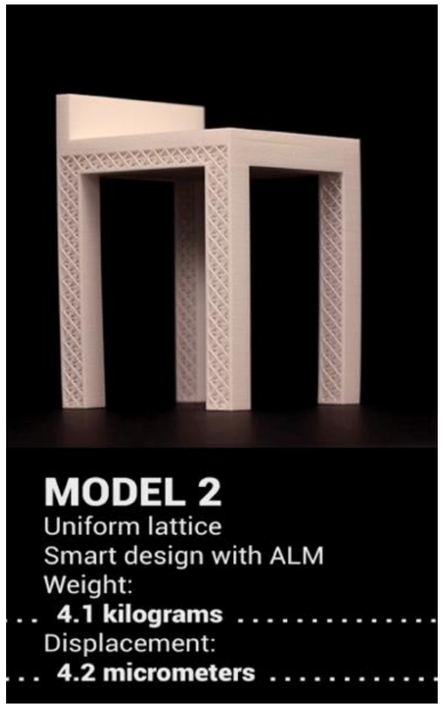
Wasim Younis

Simulation Manager

I do not need Simulation

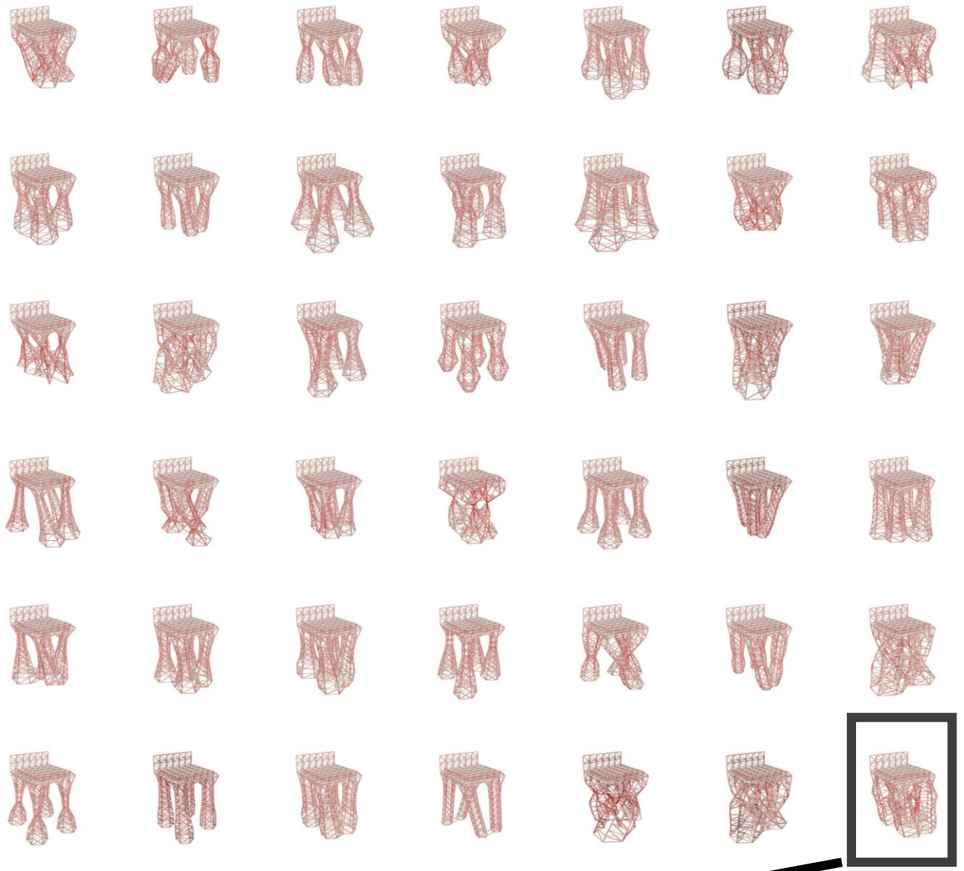
My products are too simple to need Simulation

MODEL 1
Solid bars
Traditional design
Weight:
10.3 kilograms
Displacement:
0.8 micrometers



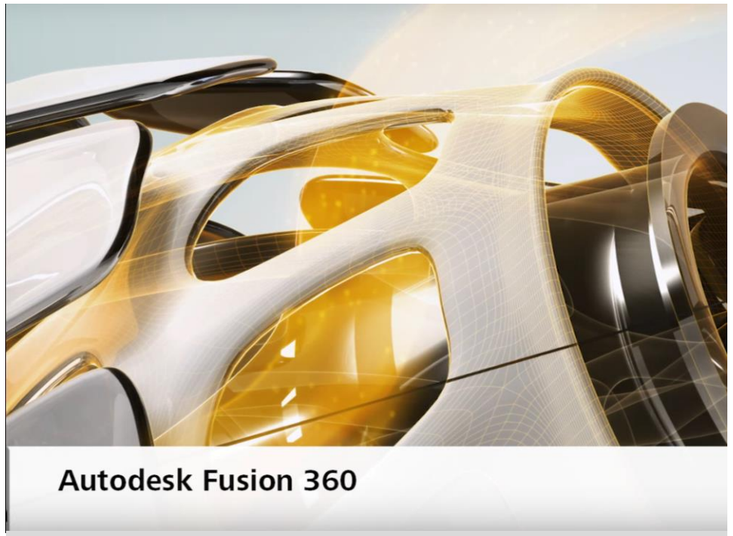
MODEL 2
Uniform lattice
Smart design with ALM
Weight:
4.1 kilograms
Displacement:
4.2 micrometers

MODEL 3
Evolved lattice
Evolutionary design with ALM
Weight:
2.9 kilograms
Displacement:
6.1 micrometers



Simulation is too Expensive

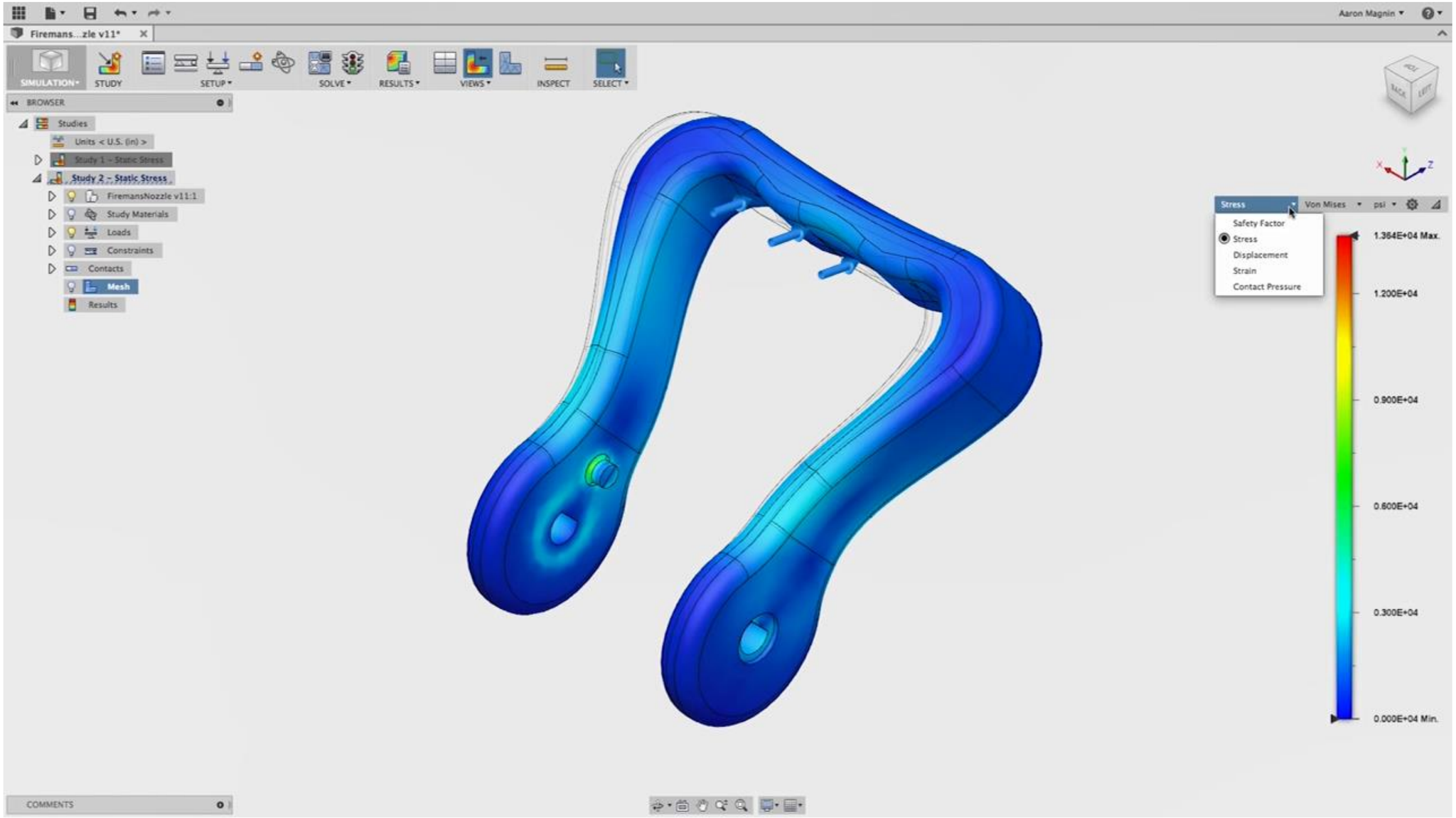
Is included in Inventor Professional



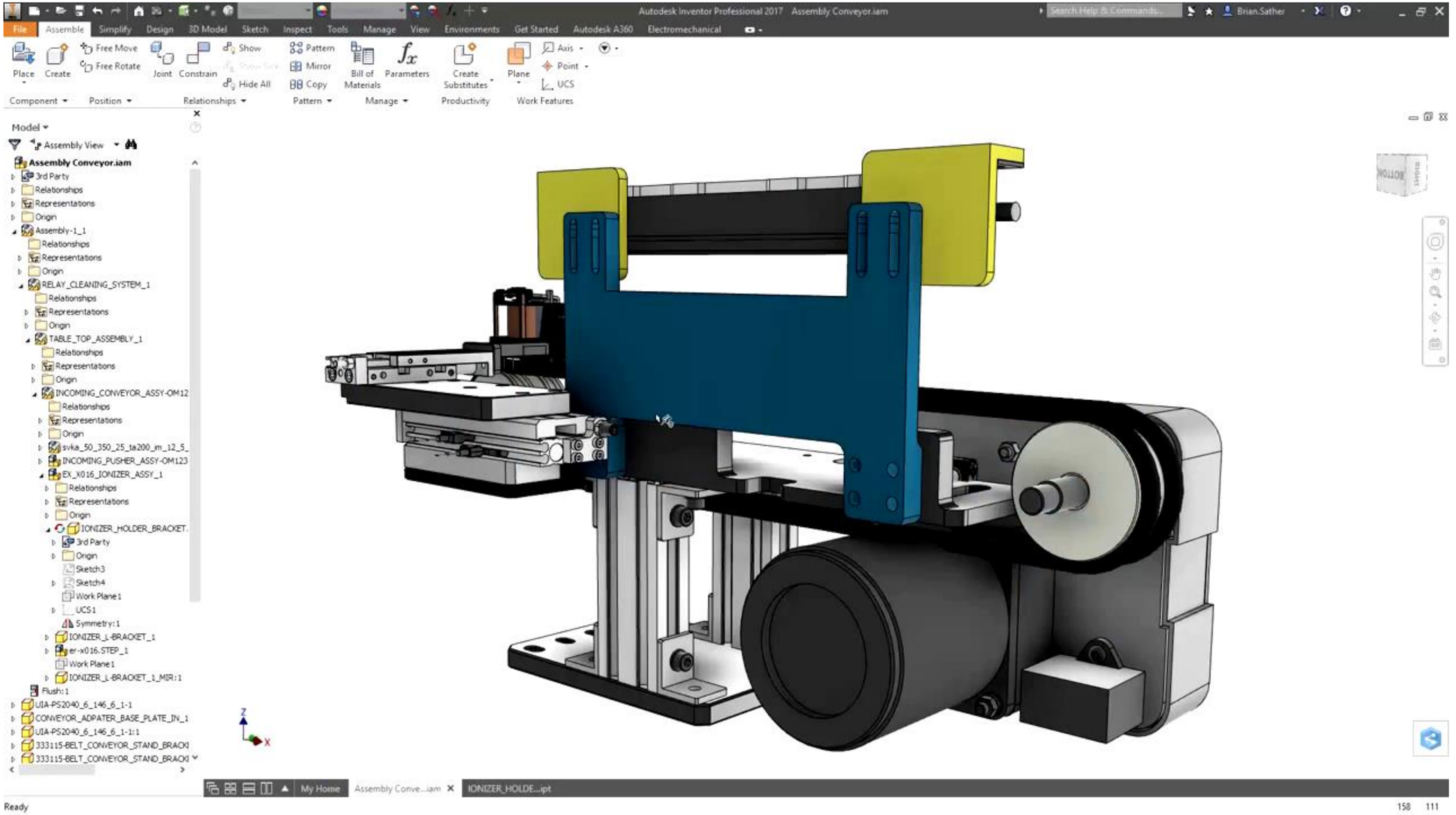
£276/year to £1,350/year

£3325/year

Simulation is Difficult



Simulation is only for predicting failure

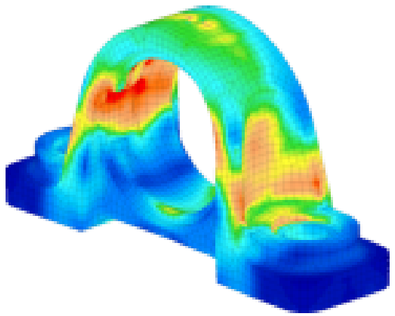


So lets look at solutions available today

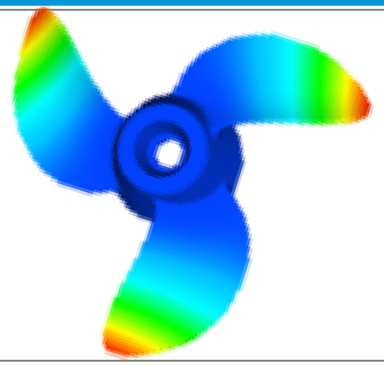
To help us make better informed decisions

Inventor Simulation - Capabilities

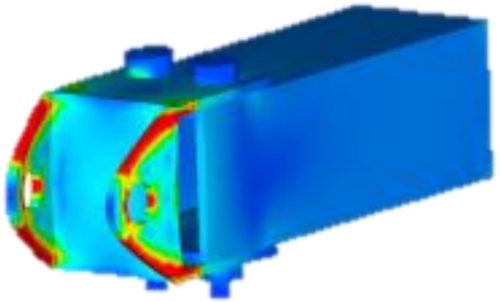
Linear Statics



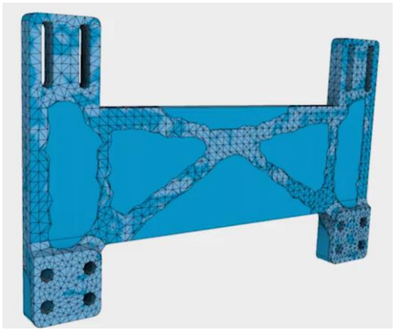
Normal Modes



Assembly Modeling with Contact – No friction

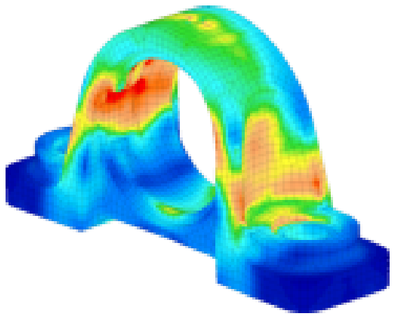


Shape Generator

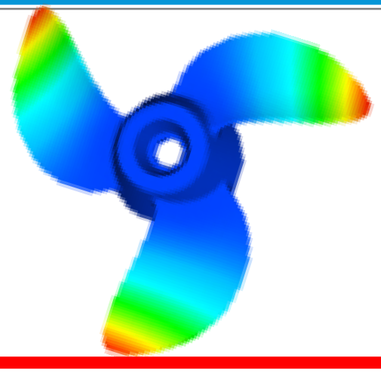


Nastran In-CAD - Capabilities

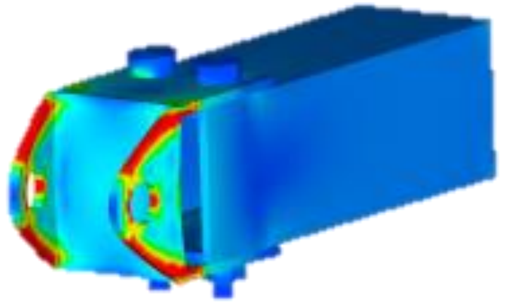
Linear Statics



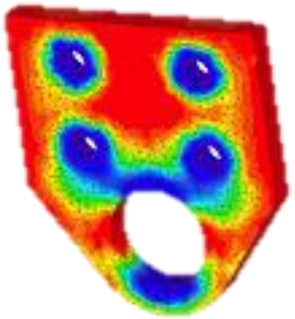
Normal Modes



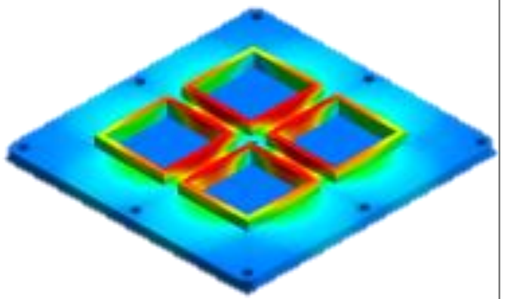
Assembly Modeling with Contact – with friction



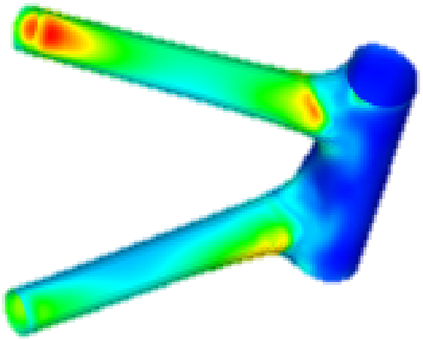
Pre-stress Static and Normal Modes



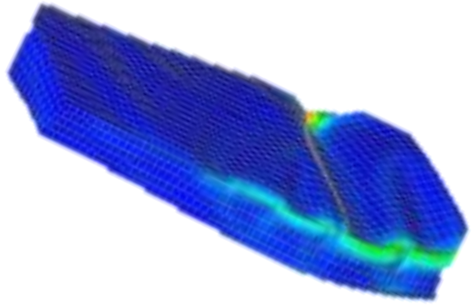
Linear Steady State Heat Transfer



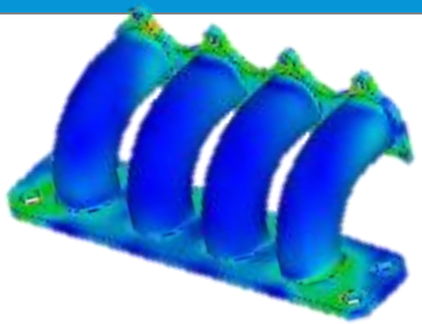
Composites



Buckling

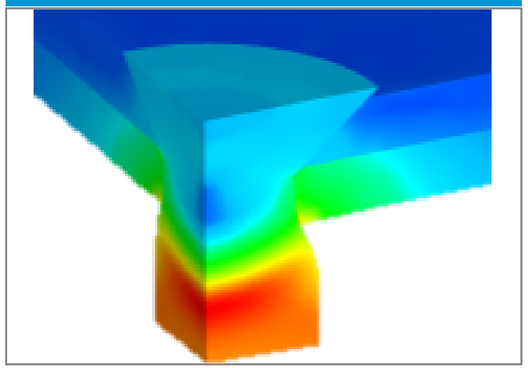


Thermal Stress

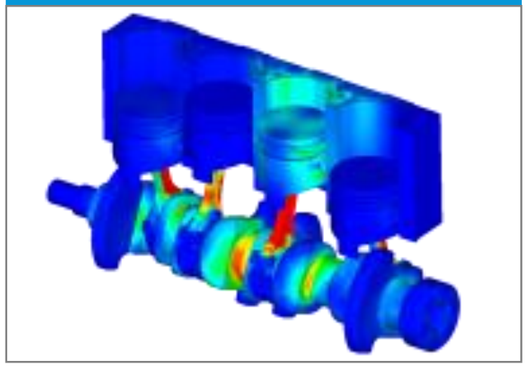


Nastran In-CAD - Capabilities

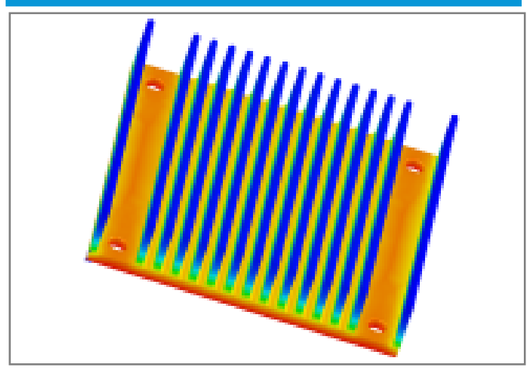
Nonlinear Statics



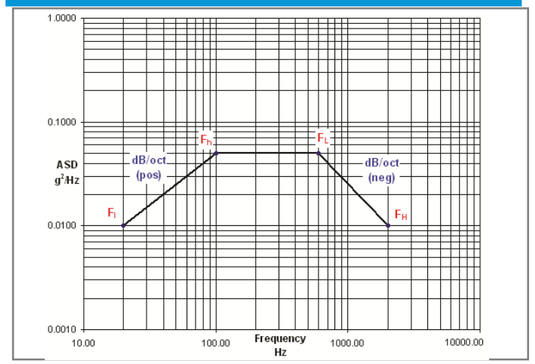
Nonlinear Transient Heat Transfer



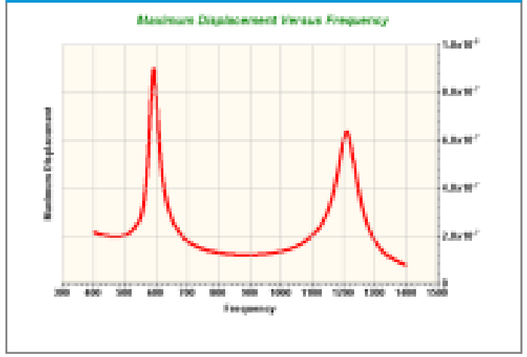
Nonlinear Steady State Heat Transfer



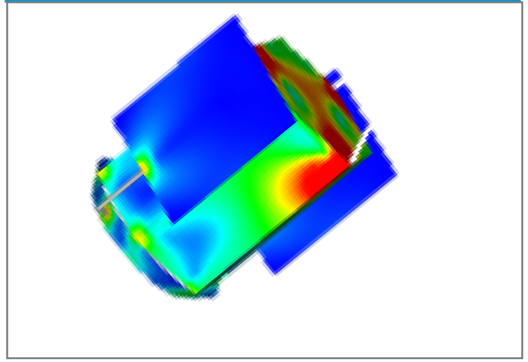
Random Response



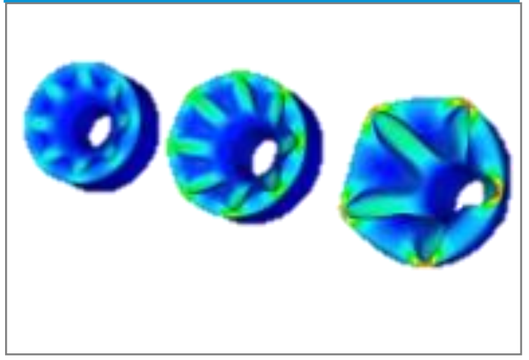
Frequency Response



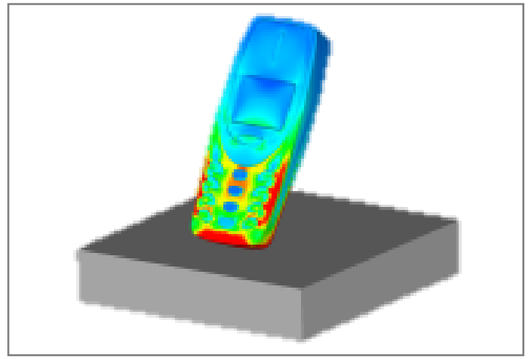
Linear and Nonlinear Transient Response



Advanced Nonlinear and Hyperelastic Materials

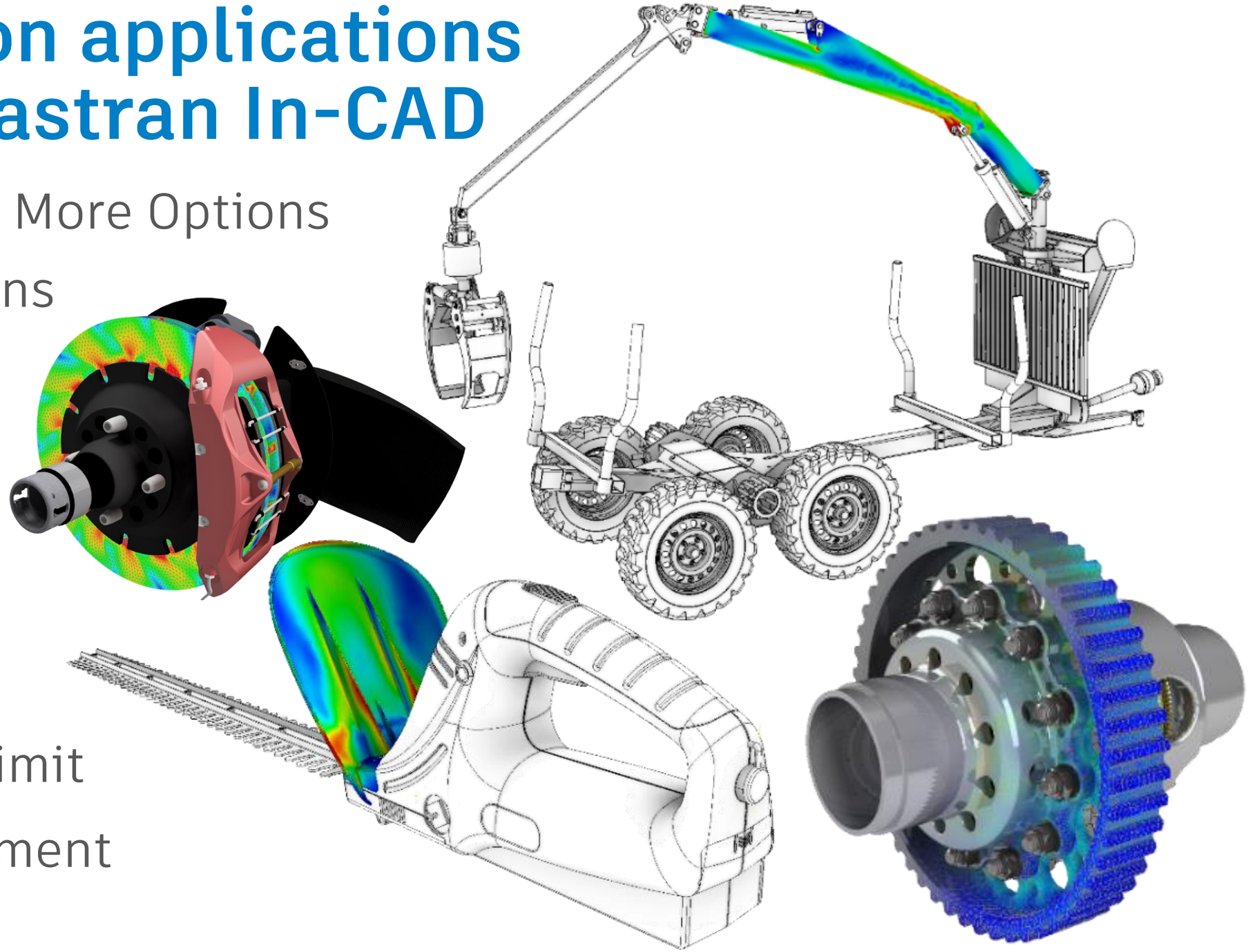


Automated Impact Analysis (AIA) and Drop Test

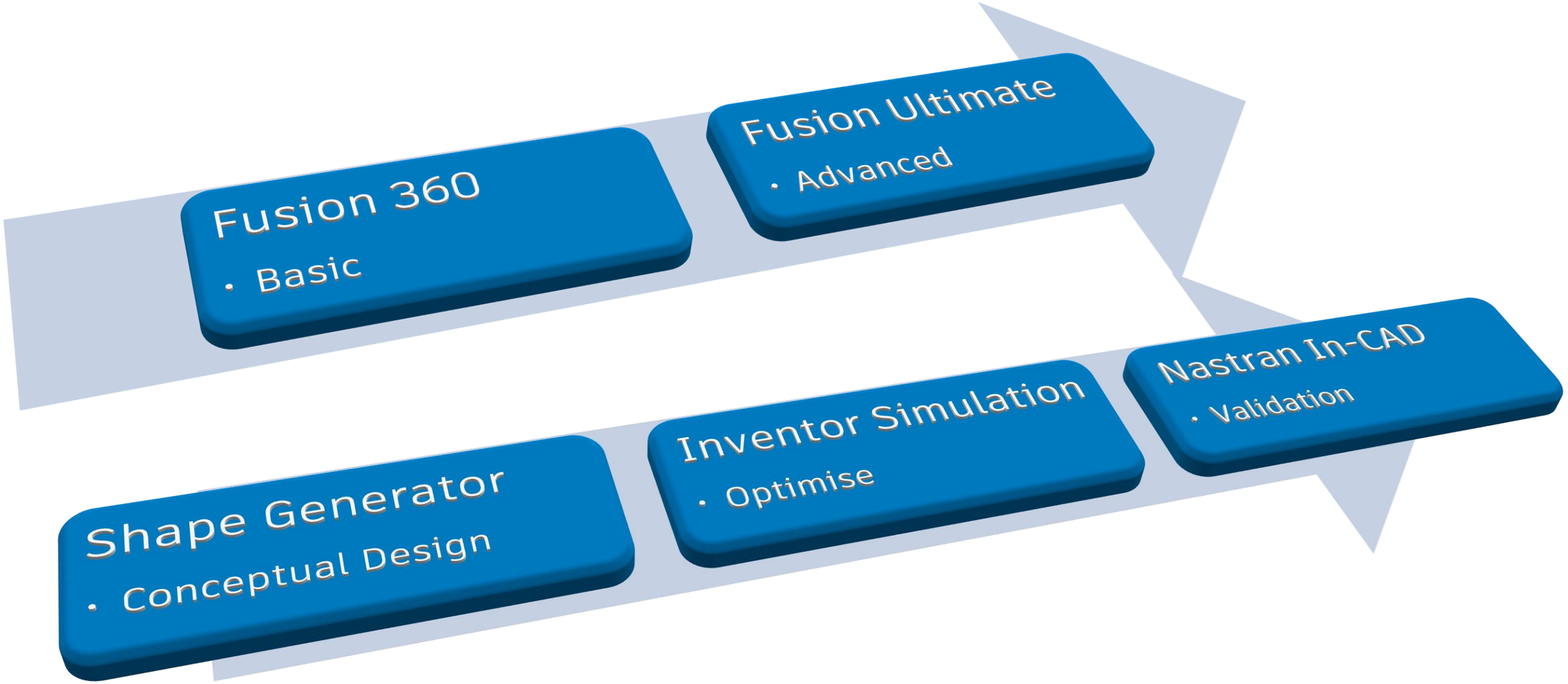


Some common applications to move to Nastran In-CAD

- Linear Analysis – More Options
- Bolted Connections
- Buckling
- Thermal Stress
- Fatigue
- Drop-test
- Non-Linear
  - Beyond Yield Limit
  - Large Displacement

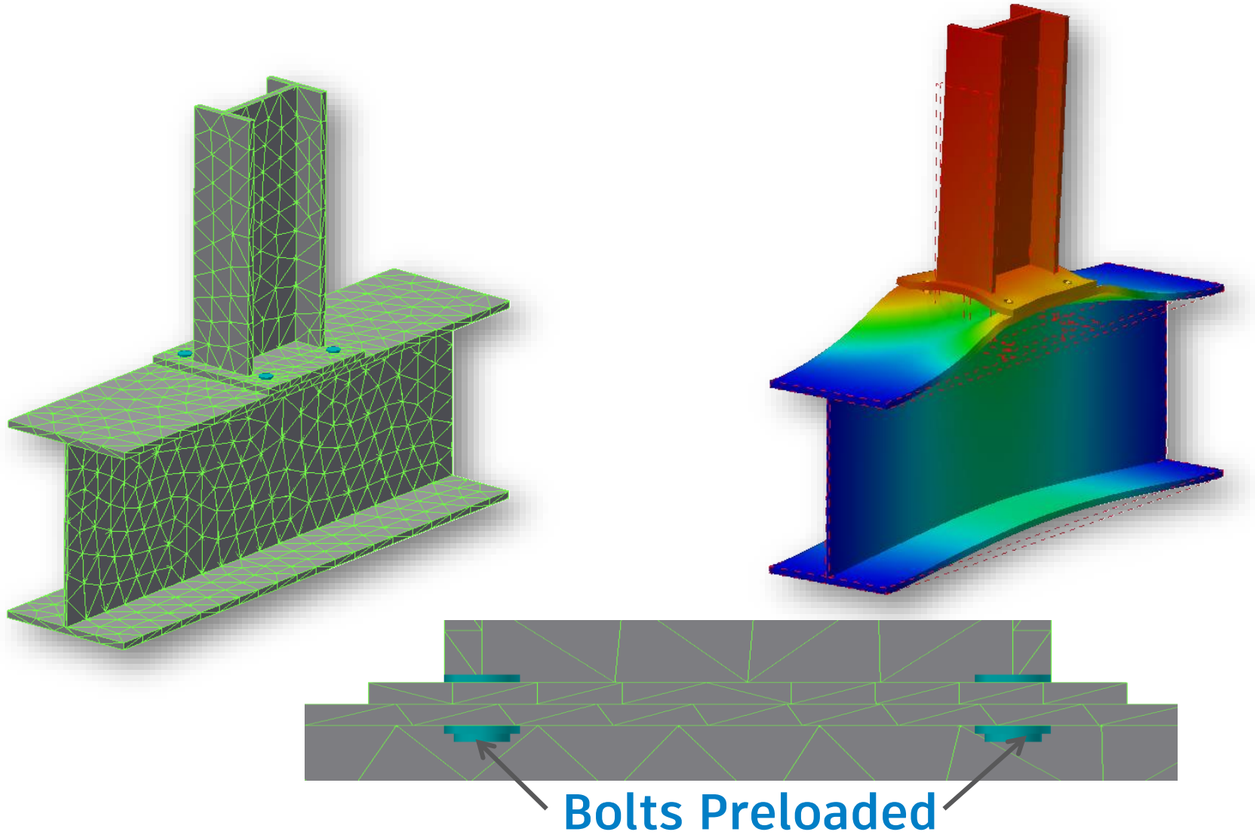


Technologies to help design with confidence



Technologies to help design with confidence
Design Example – DEMO

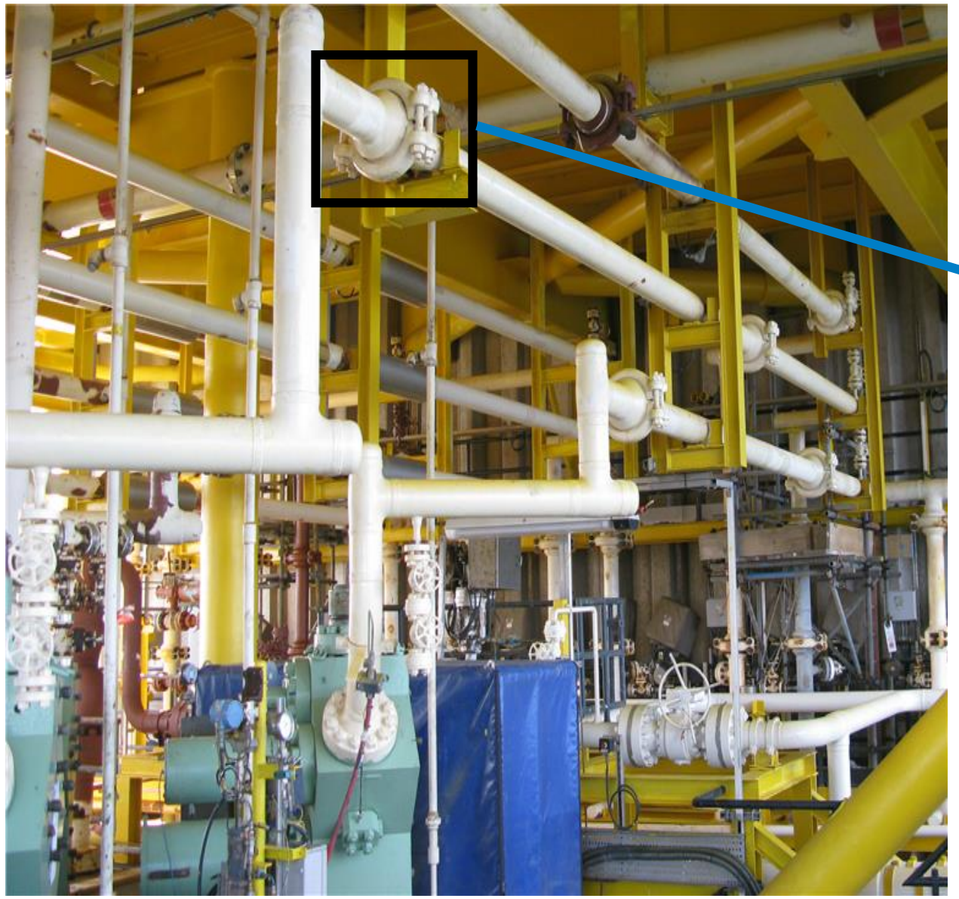
Inventor Simulation + Nastran In-CAD



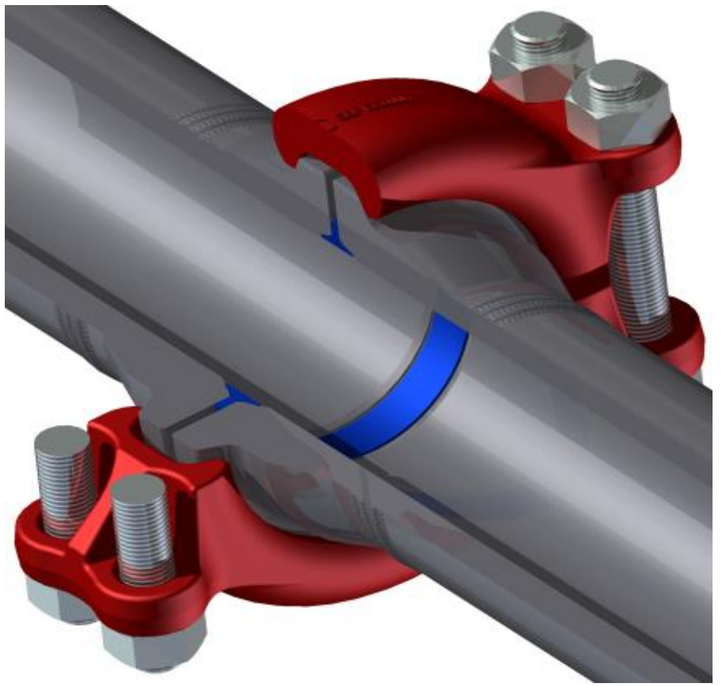
Some Customer Examples

How they have used simulation to make better informed decisions early on

Destec Engineering Ltd

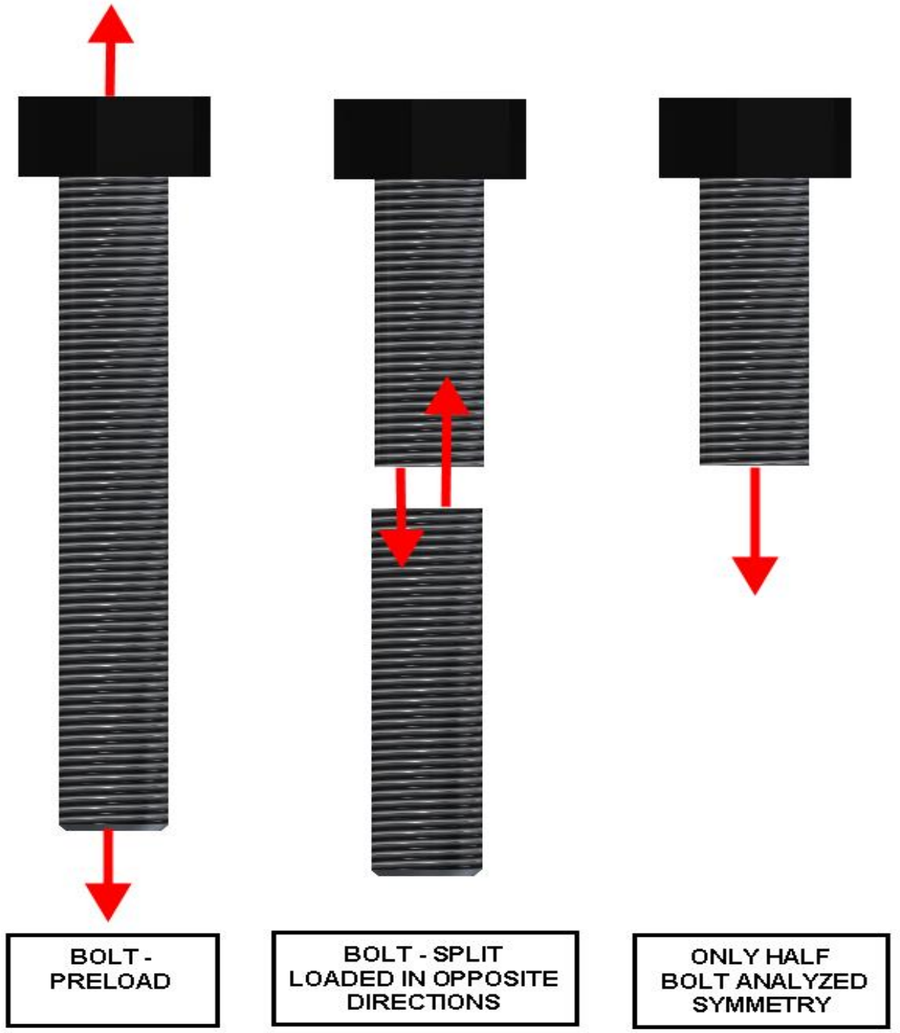


Goal: Is to make sure there is contact between seal and pipe



Design Criteria: Maximum Stress in Clamp for given bolt preload

Destec Engineering Ltd



Destec Engineering Ltd

The following equation and information will be used to determine the load to stress the bolt to a given specified value based on its diameter. This method agrees with the method given by the **American Petroleum Institute Standard API 6A**.

Bolt Size :- 1.1/8"-8UN

Nominal Bolt Size $NB = 1.125in$

Pitch of Thread $P = 0.125in$

Bolt Stress Area $A_b = \frac{\pi}{4}\cdot(NB - 1.3\cdot P)^2$

$A_b = 0.728\cdot in^2 \quad (A_b = 469.4\cdot mm^2)$

Assembly Bolt Stress $\sigma_b = 25000psi \quad (\sigma_b = 172.4\cdot MPa)$

(Load on Bolt stress Area $\sigma_b\cdot A_b = 80912.9N$)

The following information is used to calculate the bolt torque required to stress the bolt to the allowable stress.

Nominal Thread Effective Diameter $D = 1.0438in$

Half Thread Angle $\alpha = 30deg$

Coefficient of Friction $\mu = 0.12$

Inside Radius of Nut Contact Face $R_1 = \frac{1.25}{2}in$

Outside Radius of Nut Contact Face $R_2 = \frac{1.813}{2}in$

Friction Torque at Thread $A = \frac{\mu\cdot A_b\cdot\sigma_b\cdot D}{2\cdot\cos(\alpha)}$

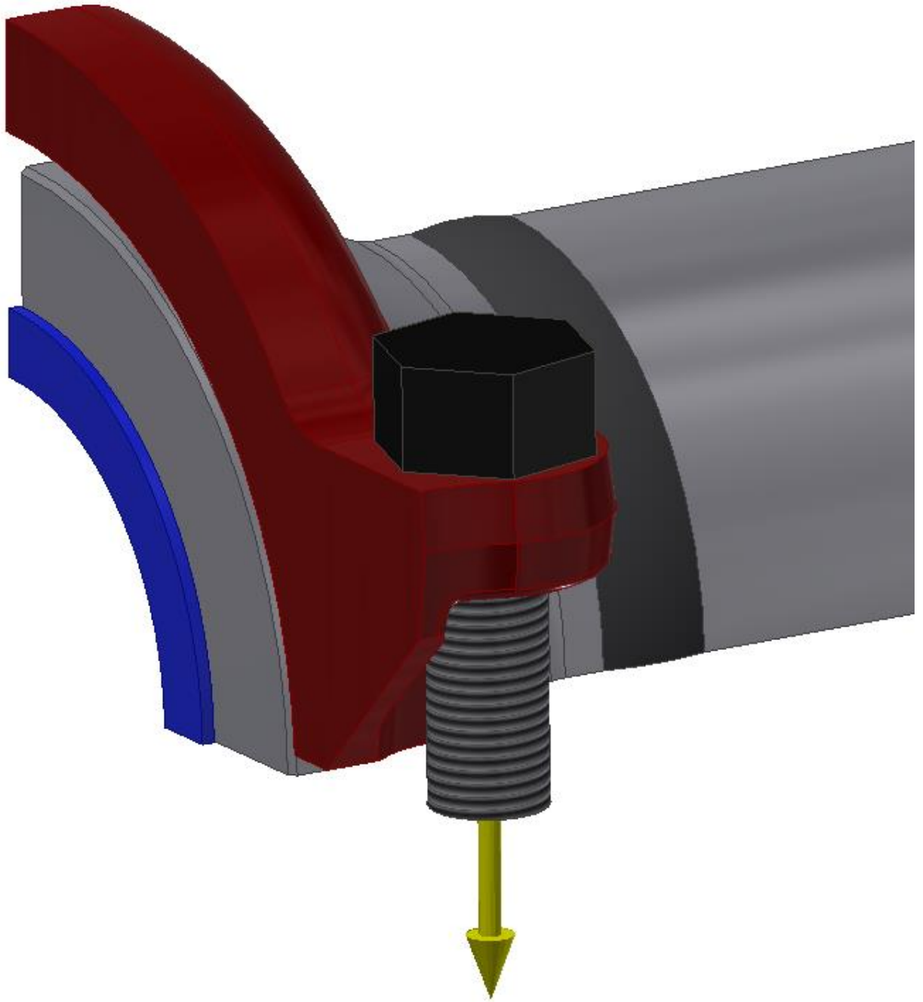
Friction Torque between Nut Face and Clamp/Cover $C = \left(2\cdot\mu\cdot A_b\cdot\frac{\sigma_b}{3}\right)\cdot\frac{R_2^3 - R_1^3}{R_2^2 - R_1^2}$

Torque Required to Stretch Bolt Without Friction $B = \frac{A_b\cdot\sigma_b\cdot P}{2\cdot\pi}$

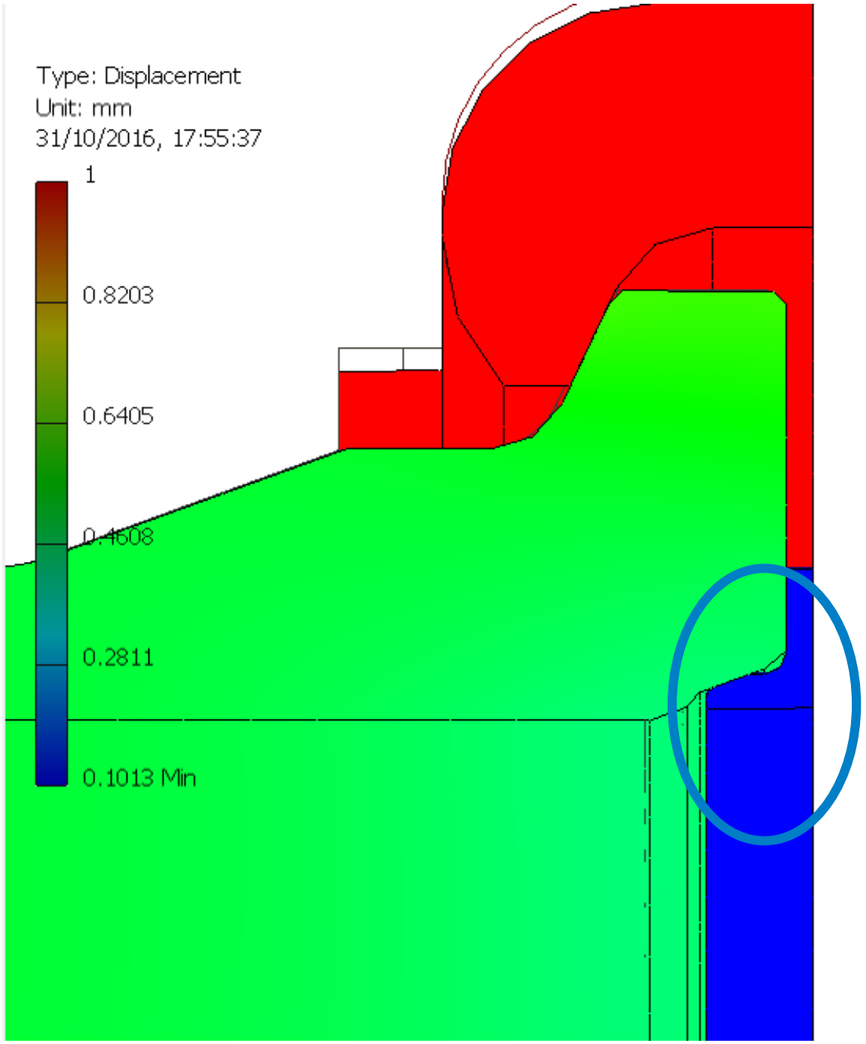
Total Torque Required $T = (A + B + C)$

$T = 280.6\cdot lbfft \quad (T = 380.5\cdot N\cdot m)$

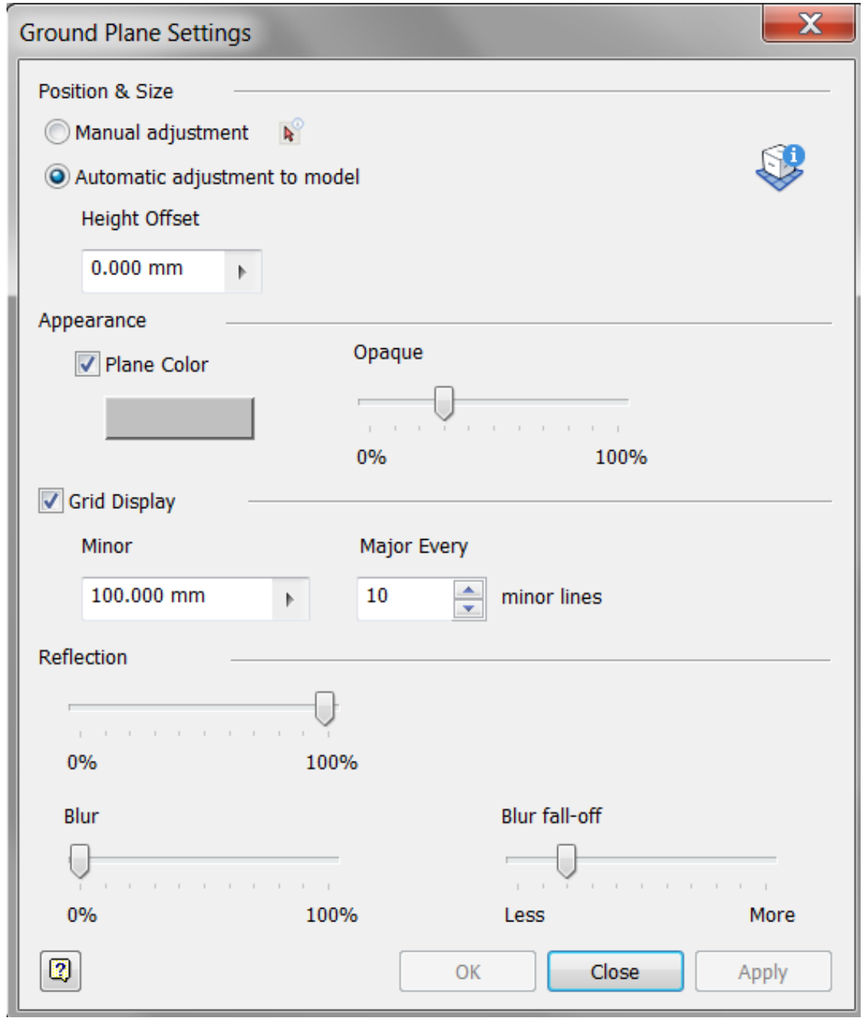
Destec Engineering Ltd

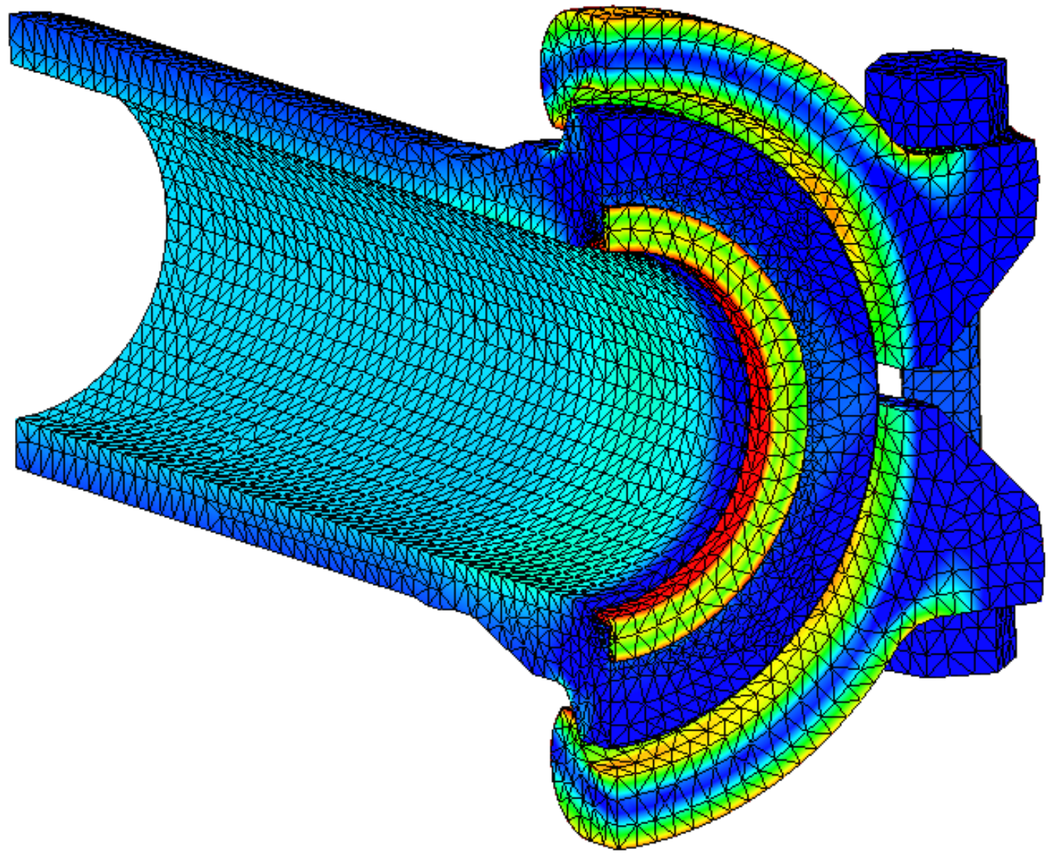


Destec Engineering Ltd



Destec Engineering Ltd





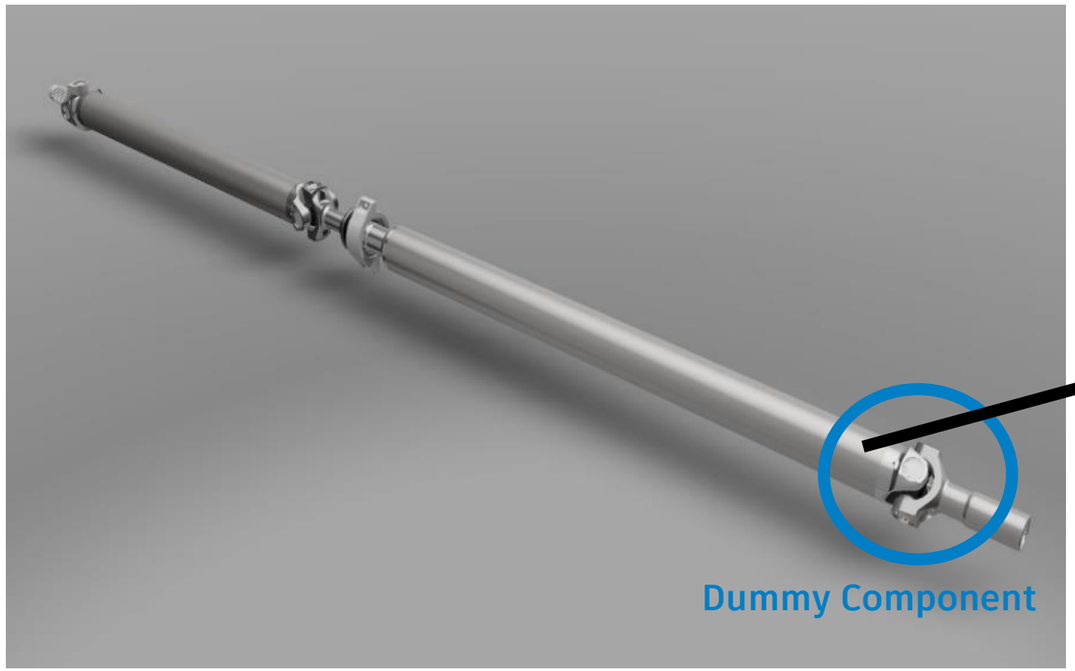
GKN Land Systems Ltd

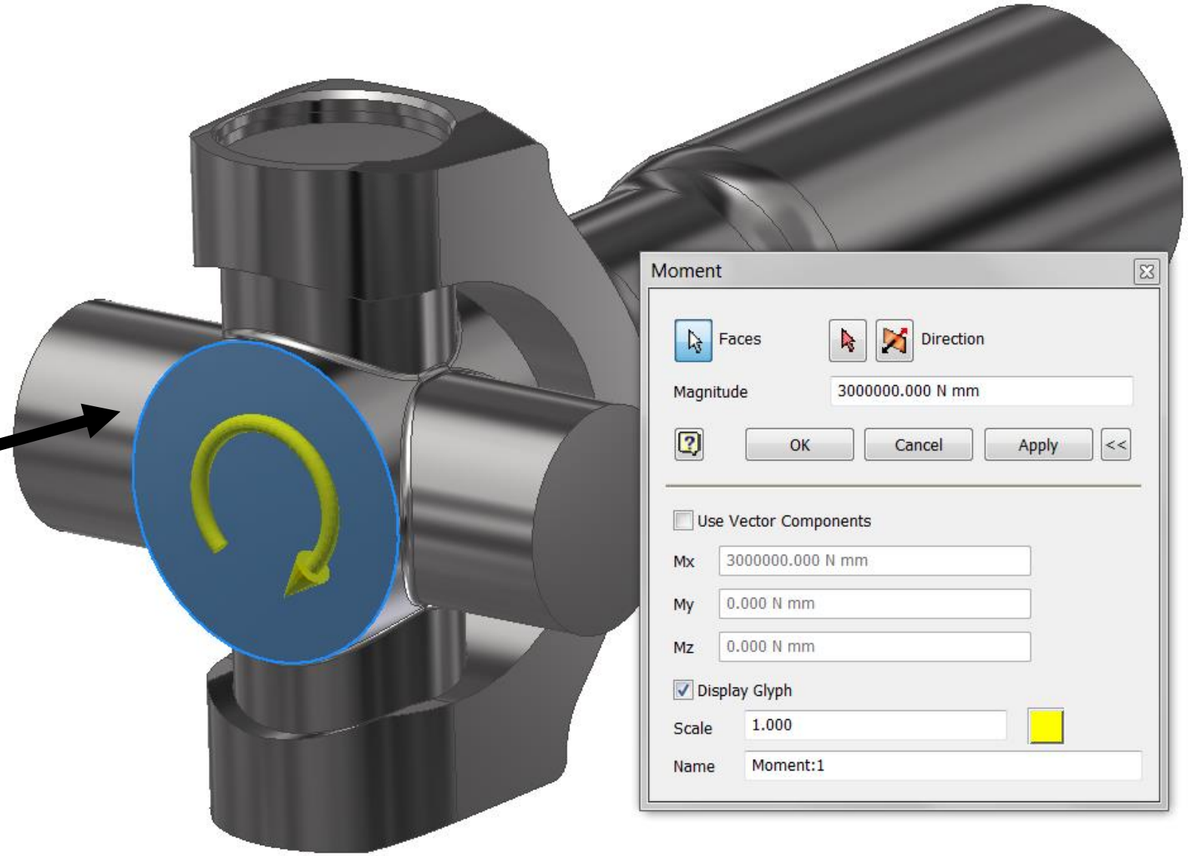
Goal: Is to determine operating stress of propshaft yoke

Design Criteria:

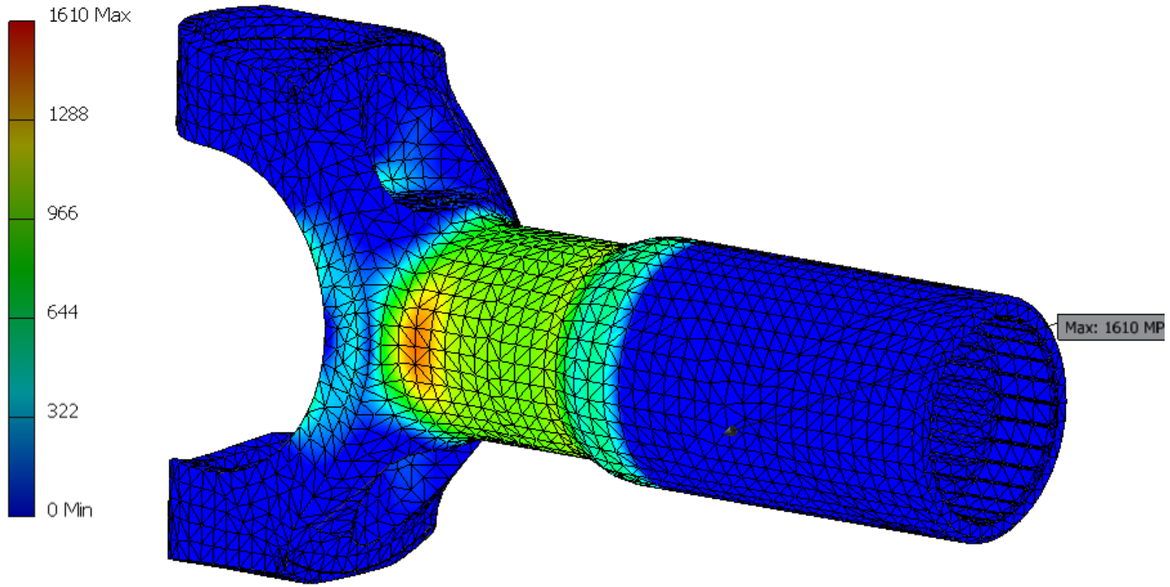
- Yield Limit is 1550 Mpa
- Moment 3000 Nm

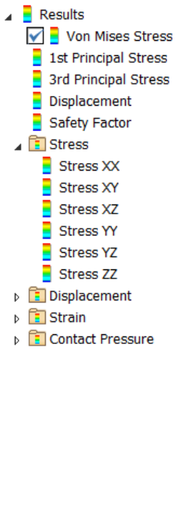
GKN Land Systems Ltd

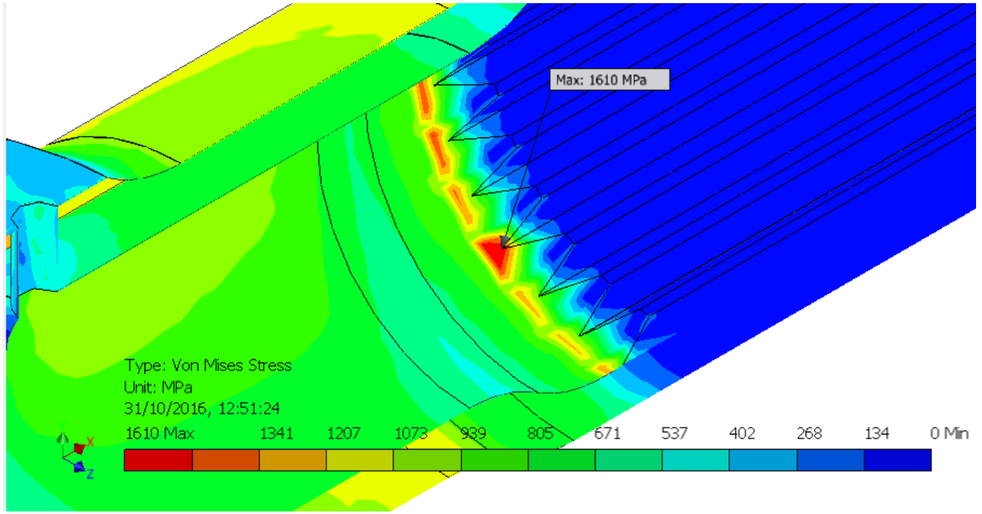


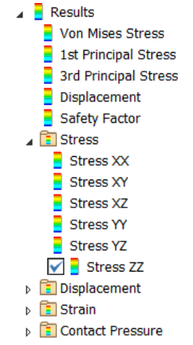


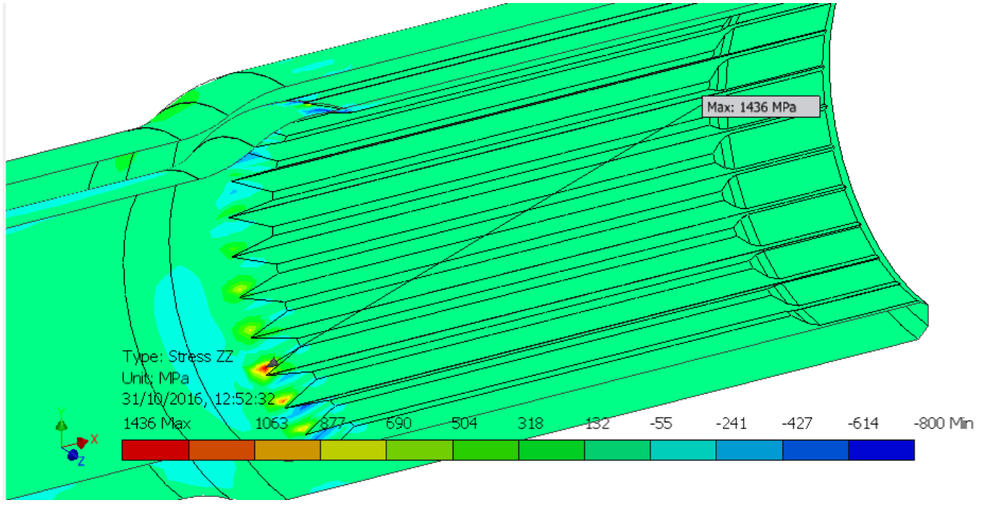
GKN Land Systems Ltd











Planet Platforms Ltd

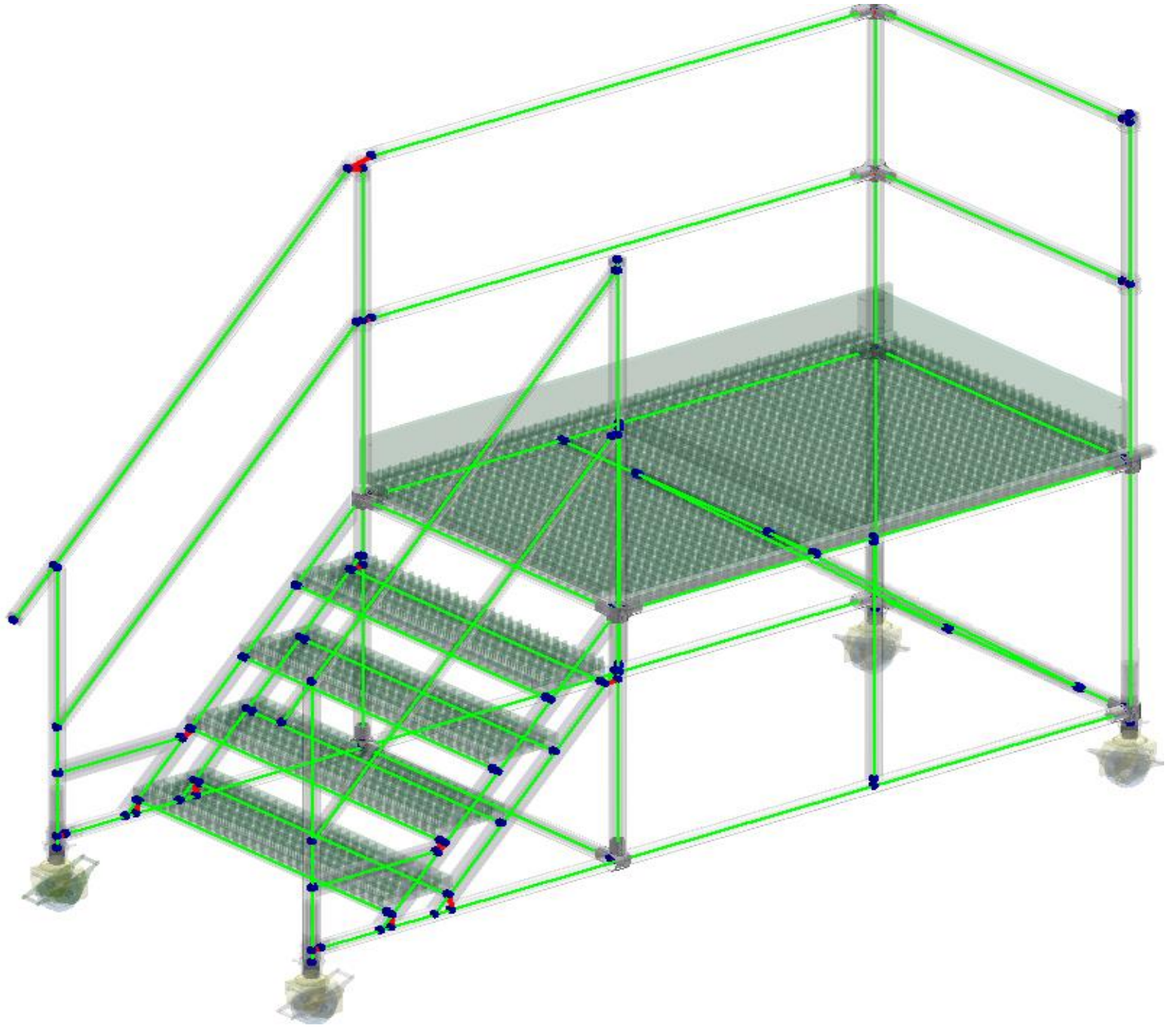
Goal:

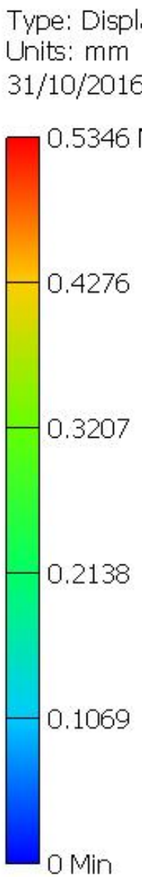
Is to make sure platform can withstand weight of two maintenance workers including their tools

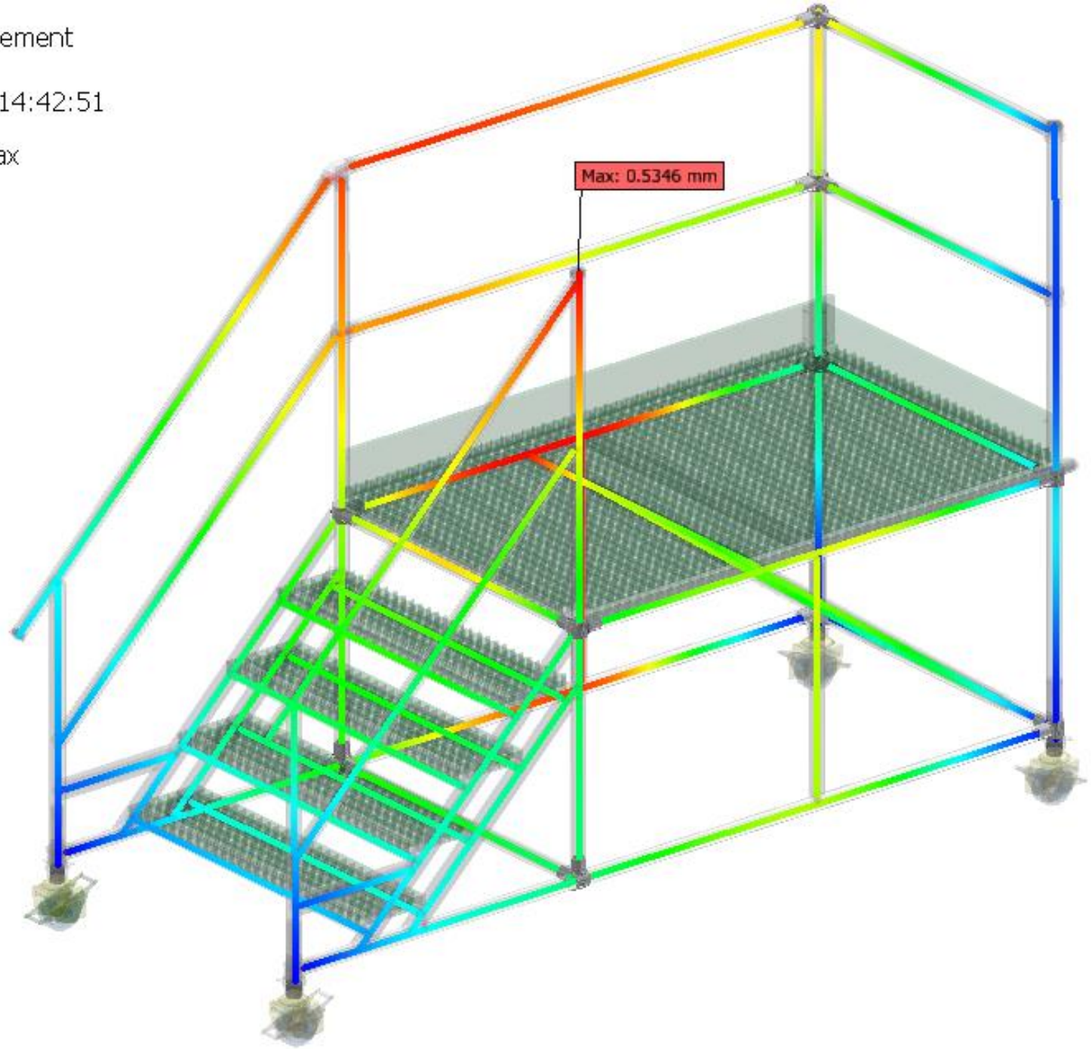
Design Criteria:

- Safety Factor of 4
- Max displacement of 10mm

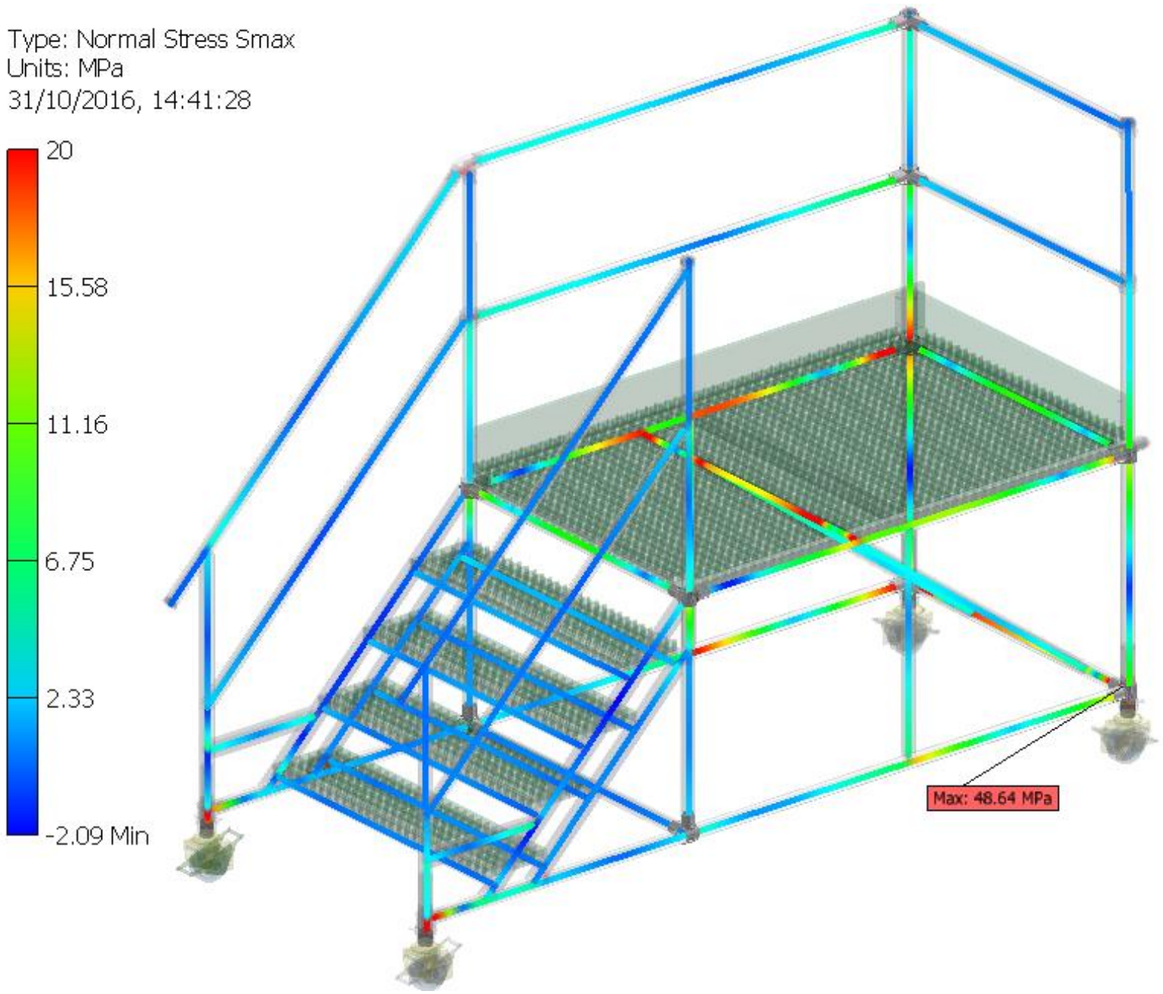
Planet Platforms Ltd

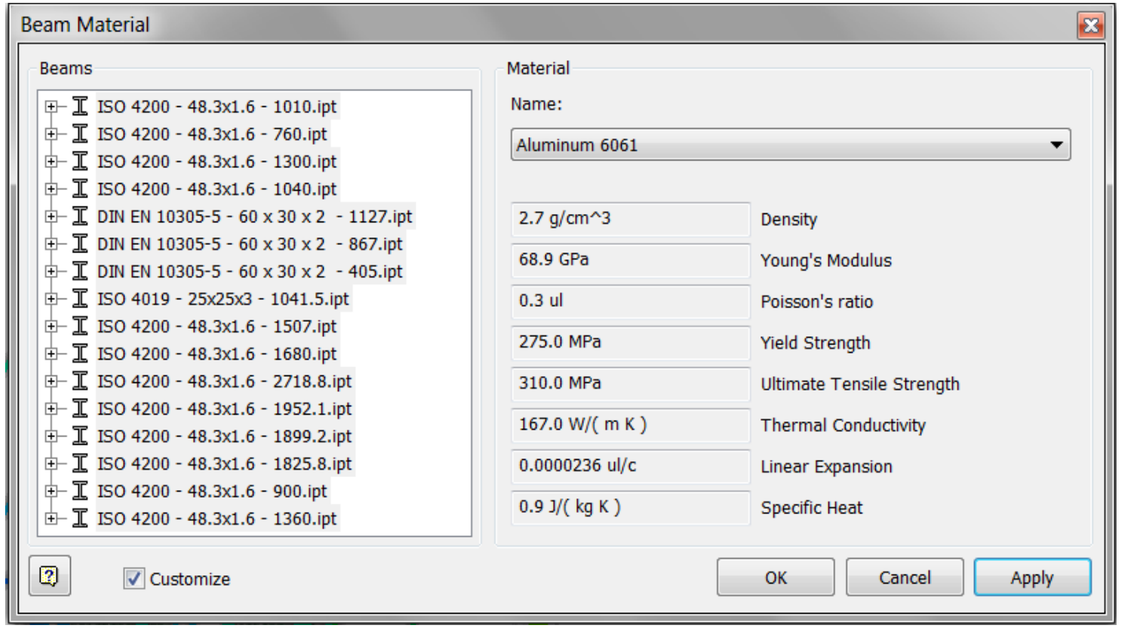




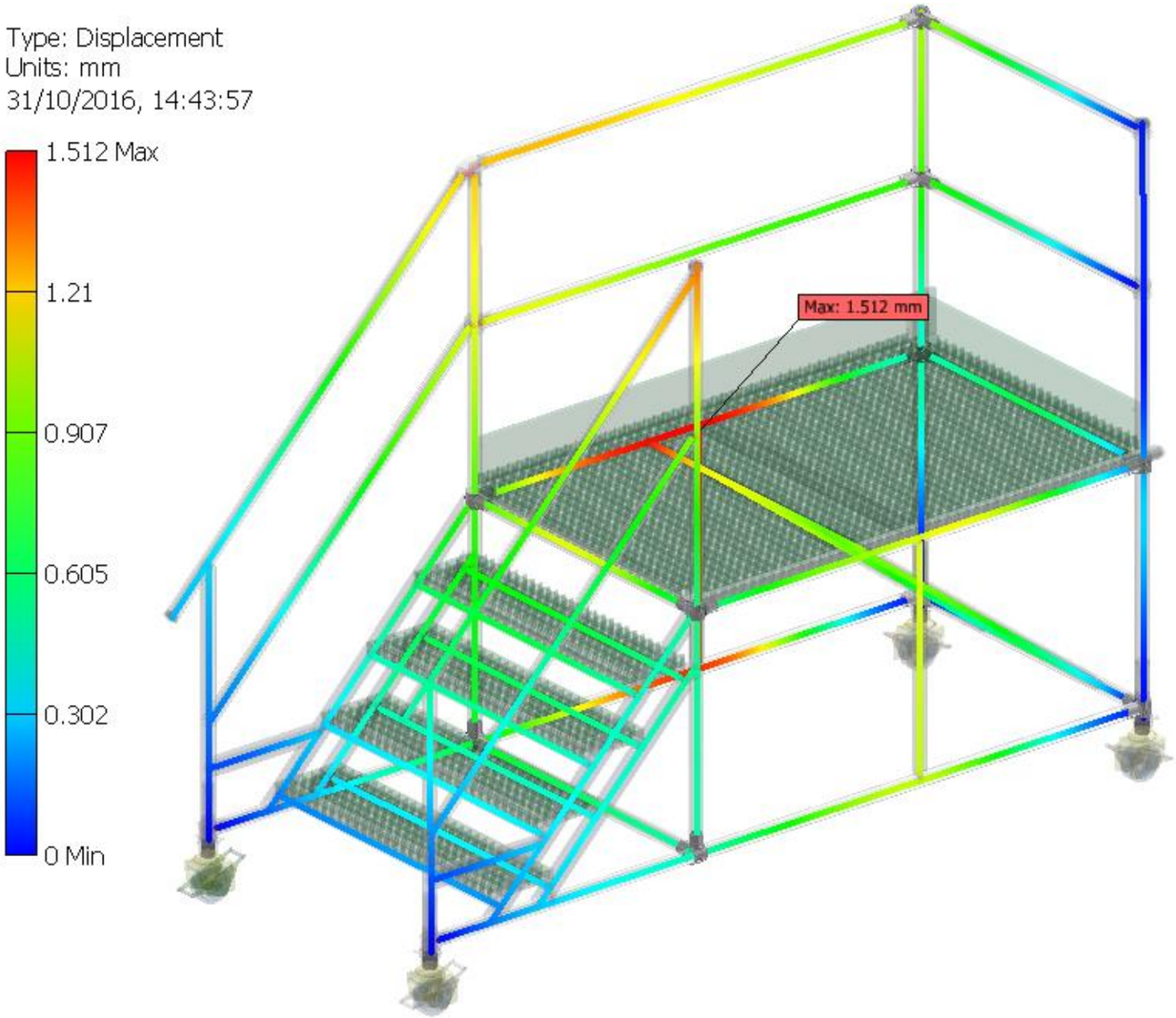


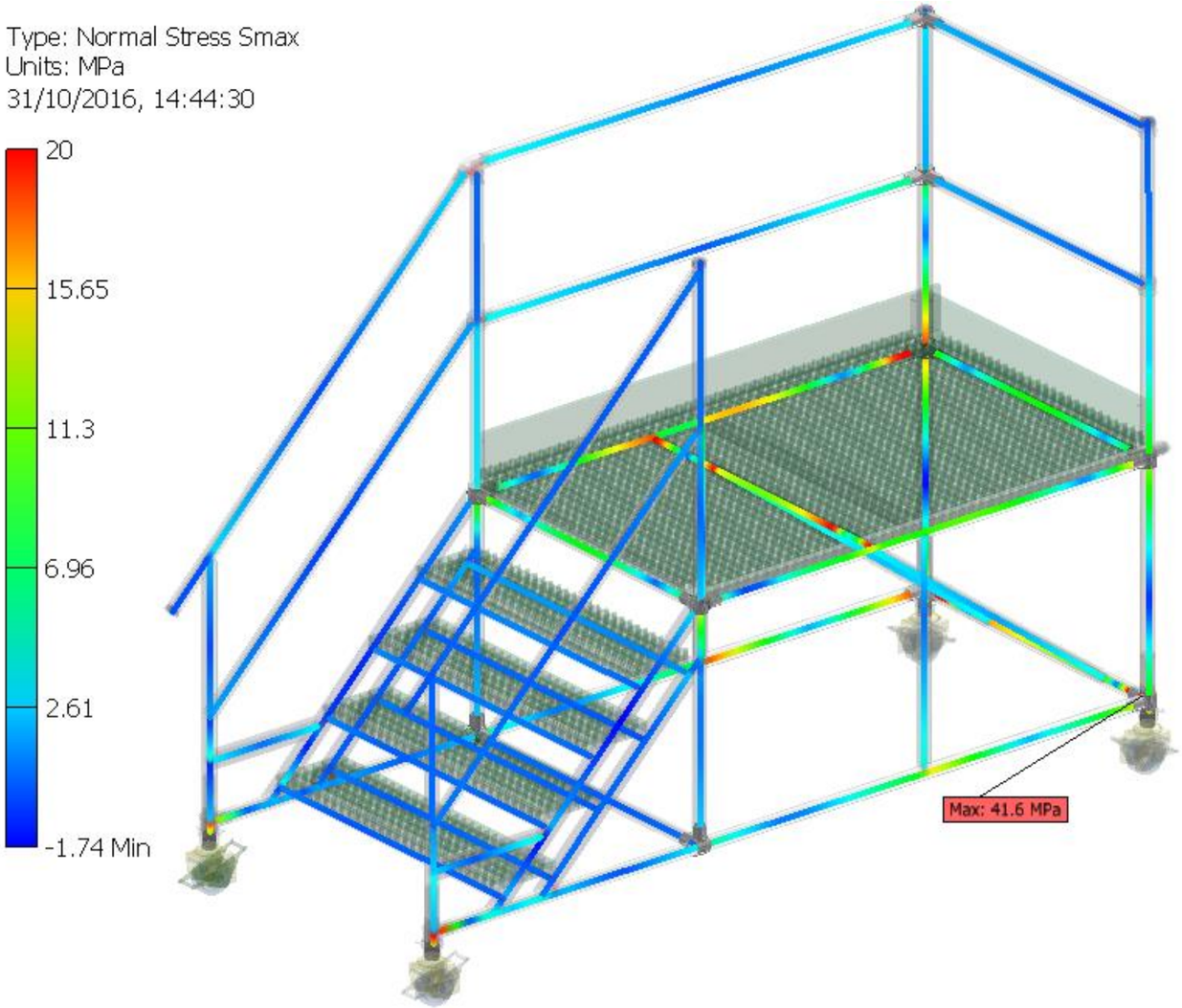
Planet Platforms Ltd



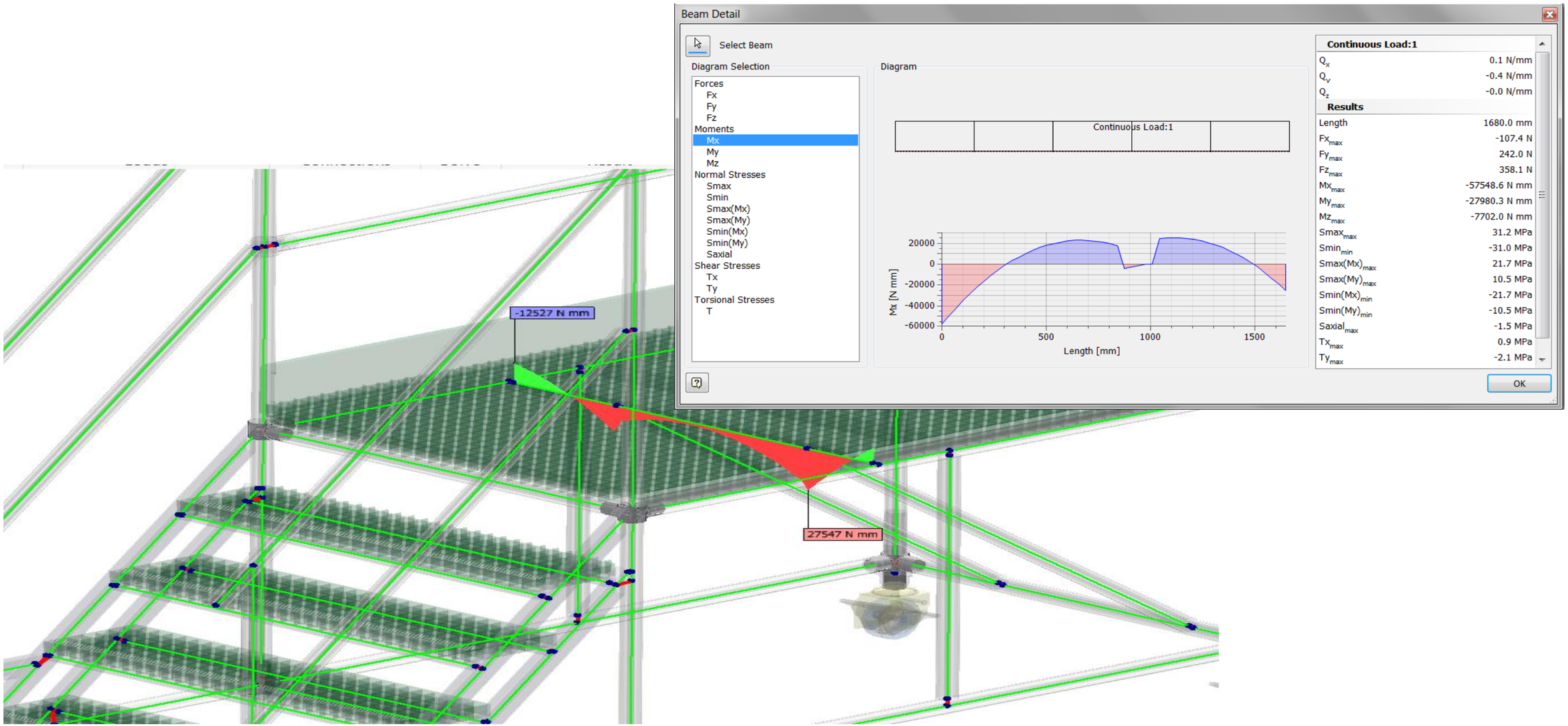


Planet Platforms Ltd





Planet Platforms Ltd

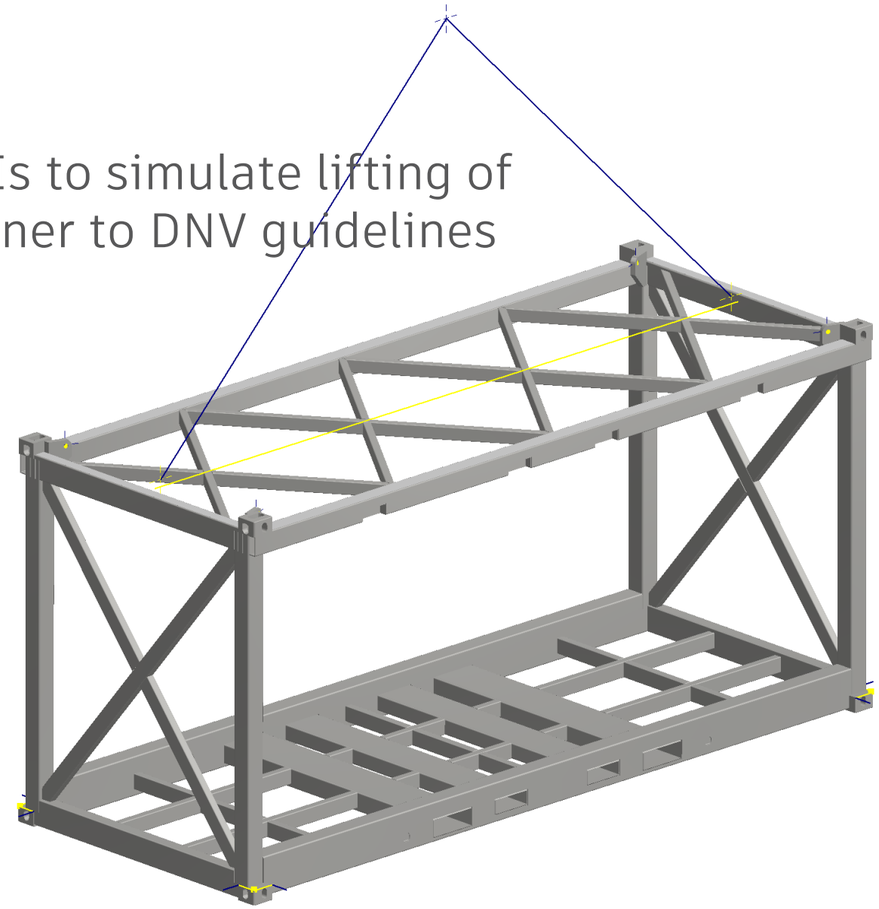


Nastran In-CAD

Take Inventor Simulation to next level

Swire Oilfield Services Ltd

Goal: Is to simulate lifting of container to DNV guidelines

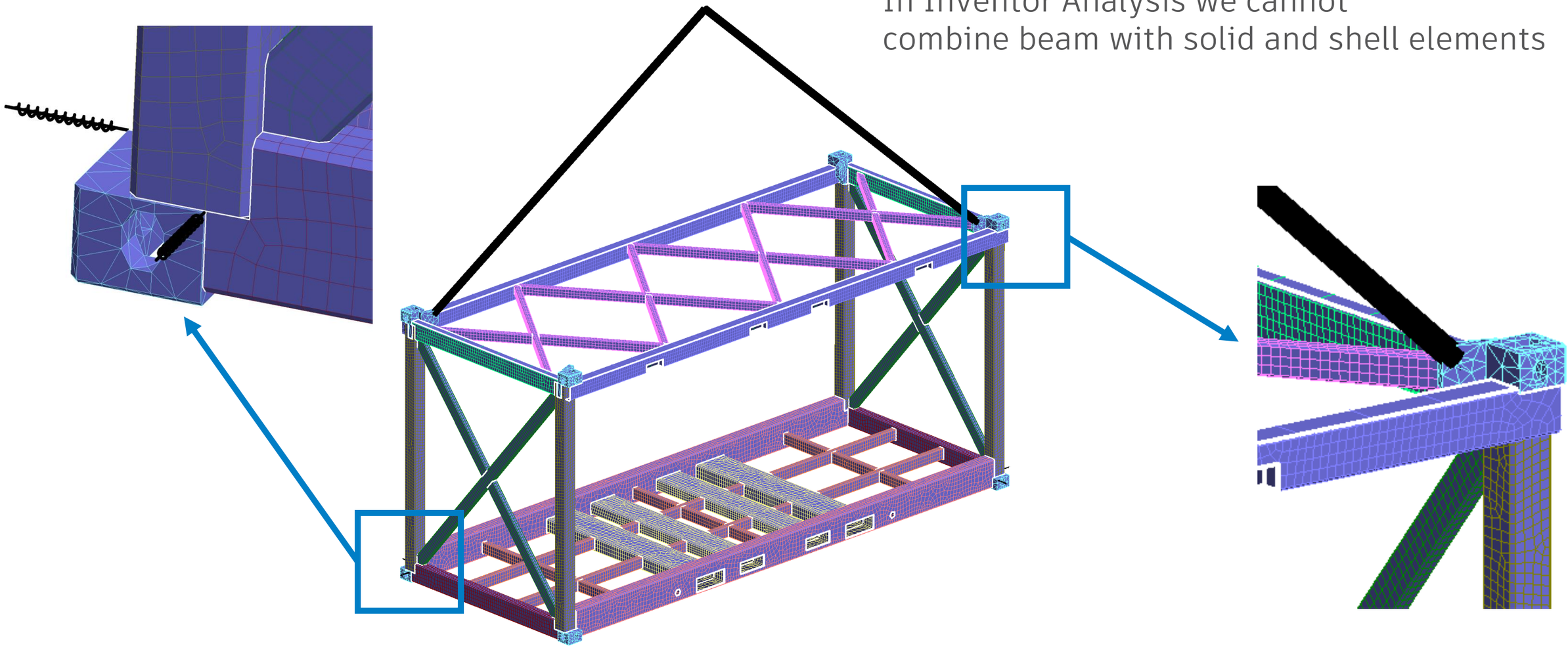


Design Criteria:

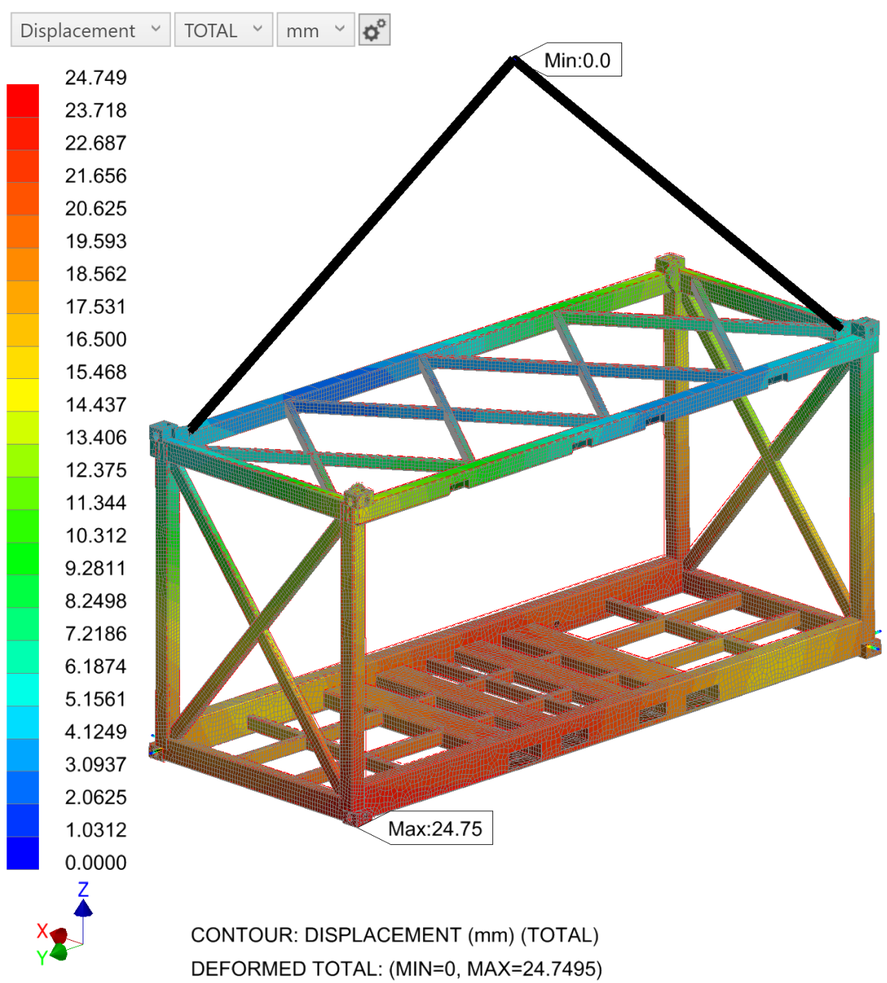
- Stress is below yield limit

Swire Oilfield Services Ltd

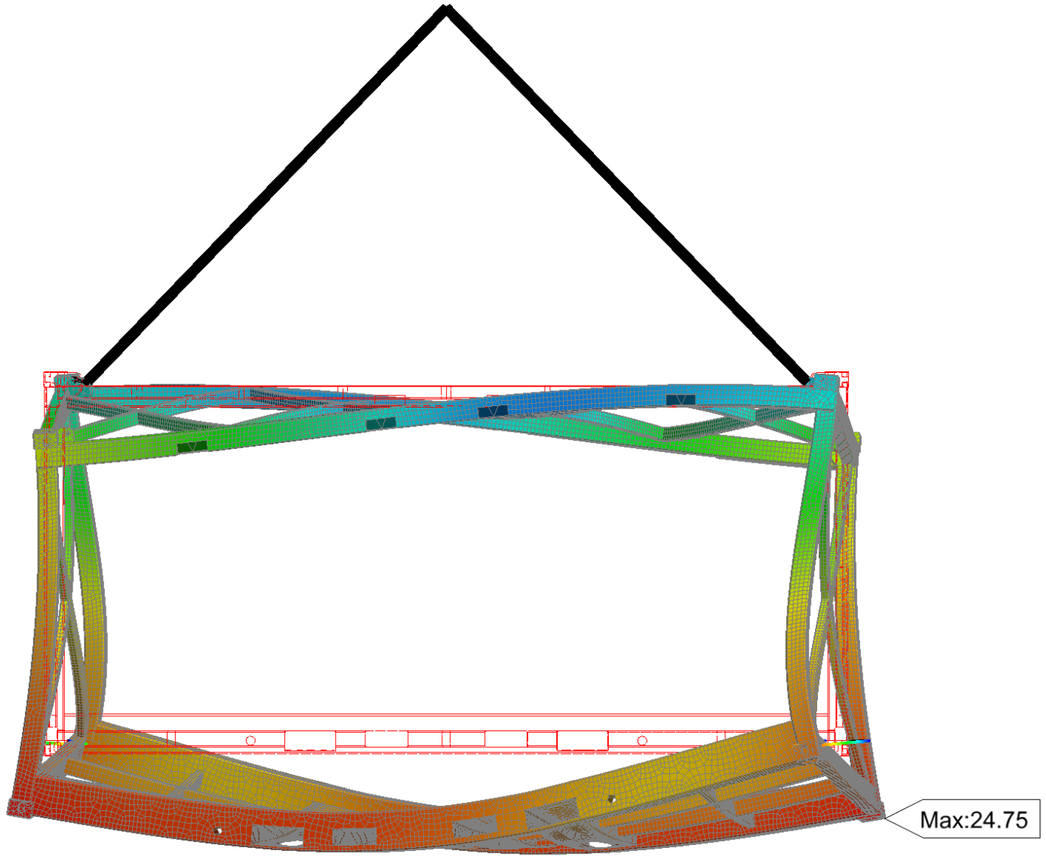
In Inventor Analysis we cannot
combine beam with solid and shell elements



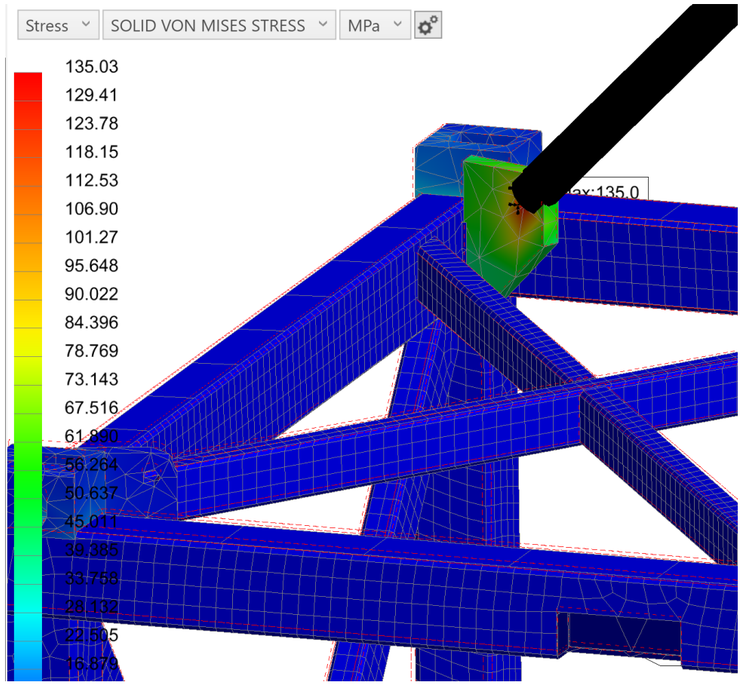
Swire Oilfield Services Ltd

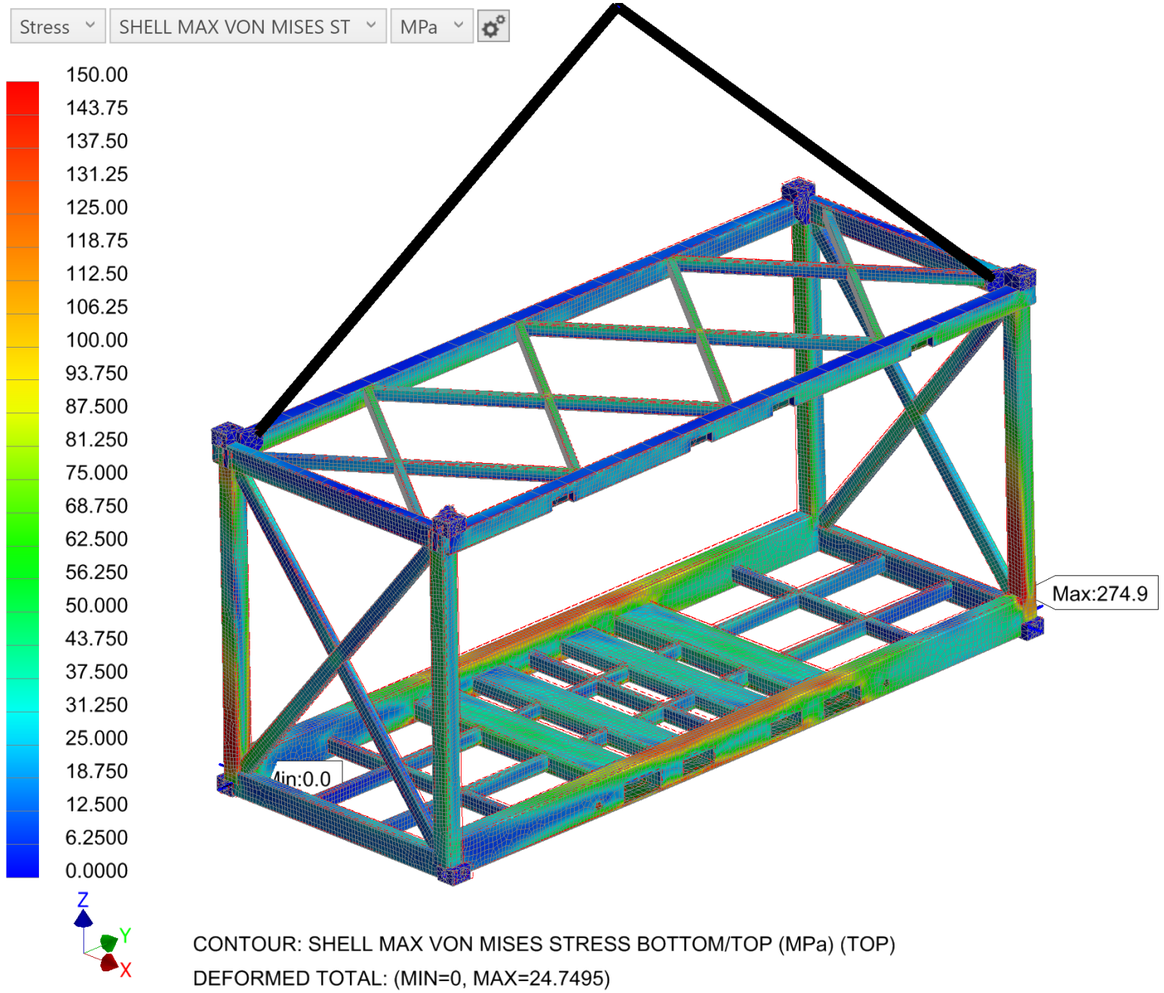


CONTOUR: DISPLACEMENT (mm) (TOTAL)
DEFORMED TOTAL: (MIN=0, MAX=24.7495)
OUTPUT SET: SUBCASE 1



Swire Oilfield Services Ltd

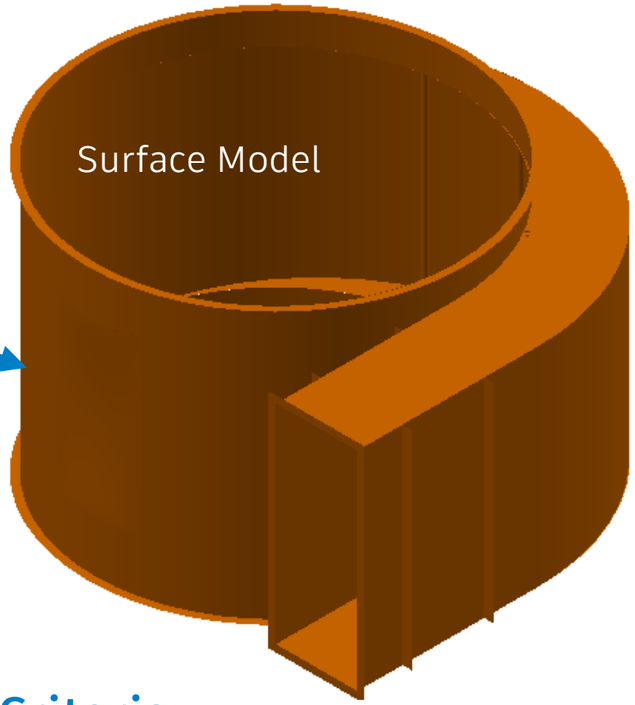




CONTOUR: SHELL MAX VON MISES STRESS BOTTOM/TOP (MPa) (TOP)
DEFORMED TOTAL: (MIN=0, MAX=24.7495)
OUTPUT SET: SUBCASE 1

Simatek A/S(Non-Linear Analysis)

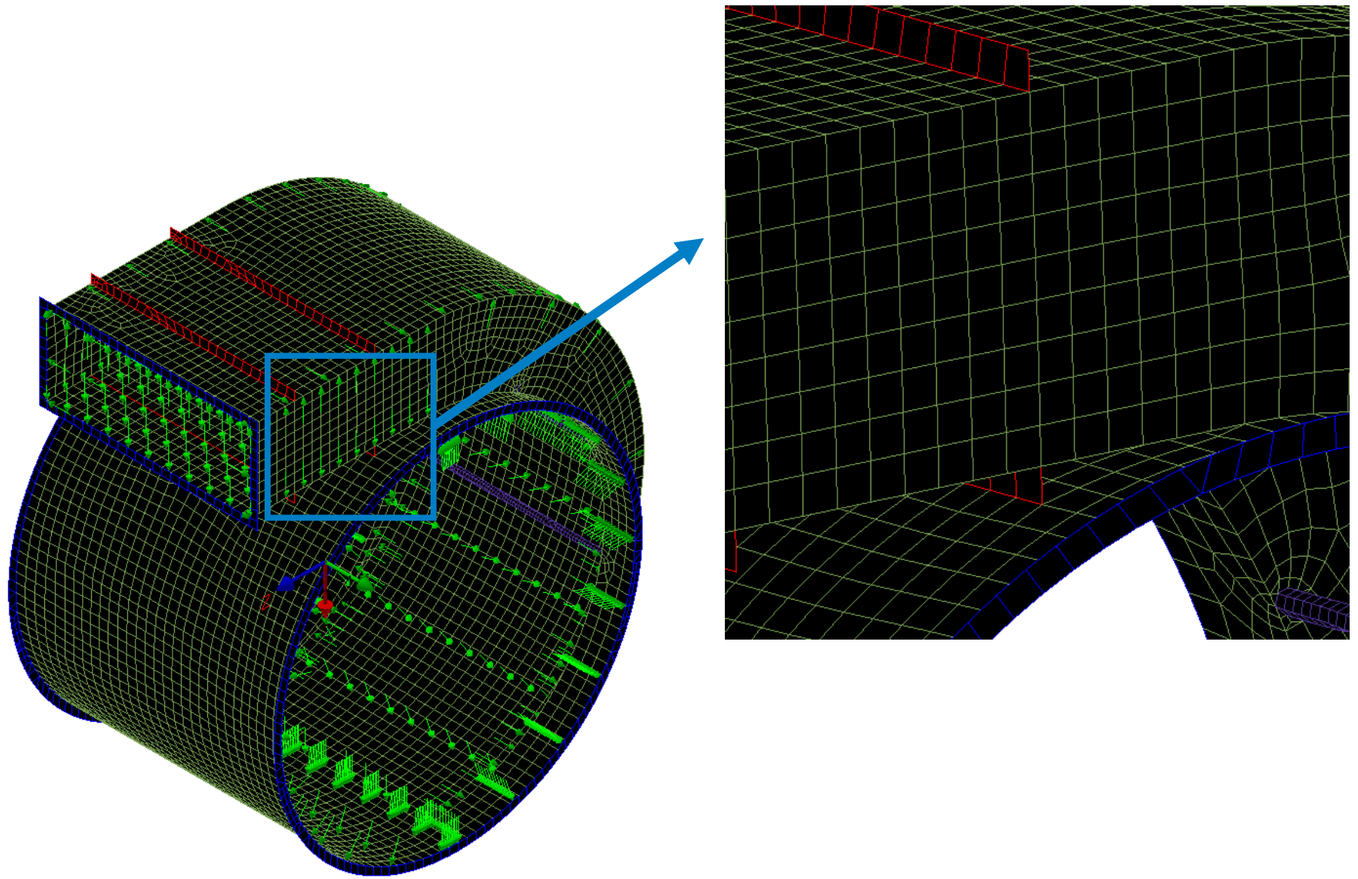
Goal: Is to determine amount of permanent deformation under loading



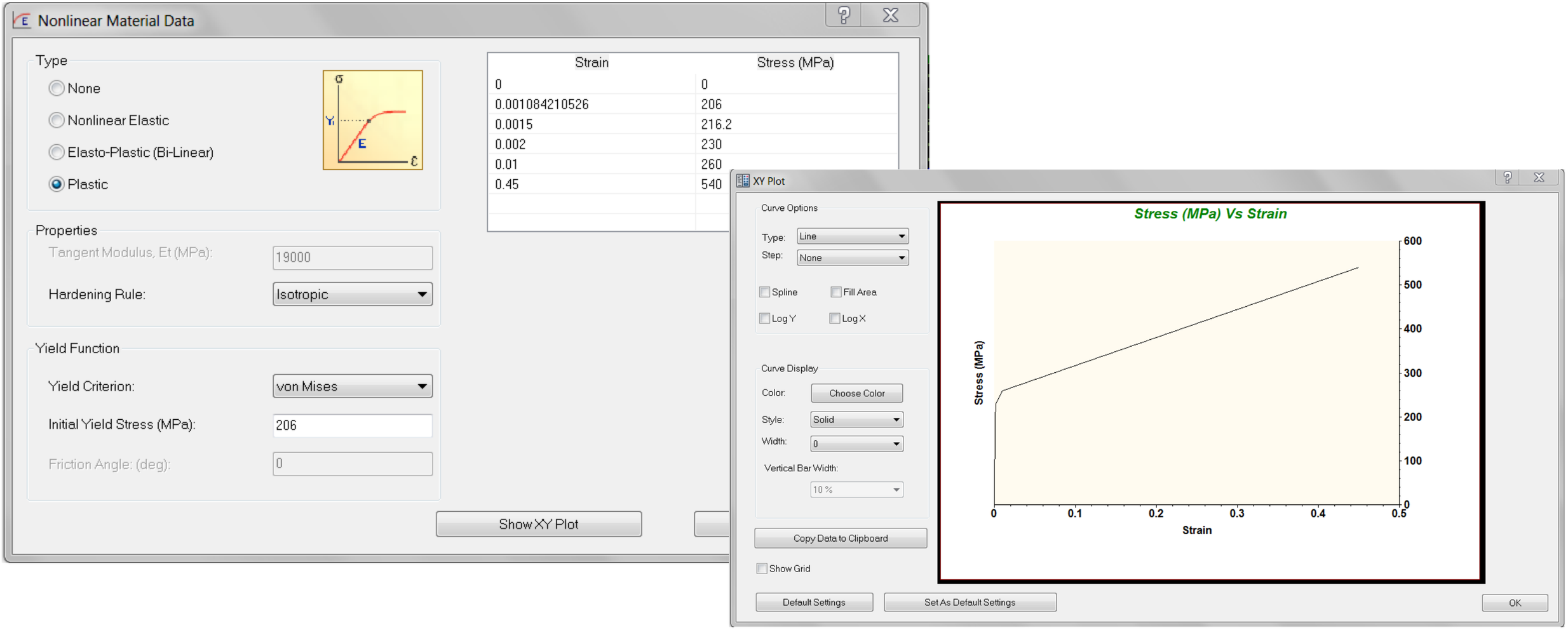
Design Criteria:

- Predefined Stress/Strain Material data
- Pressure 90 MPa

Simatek A/S

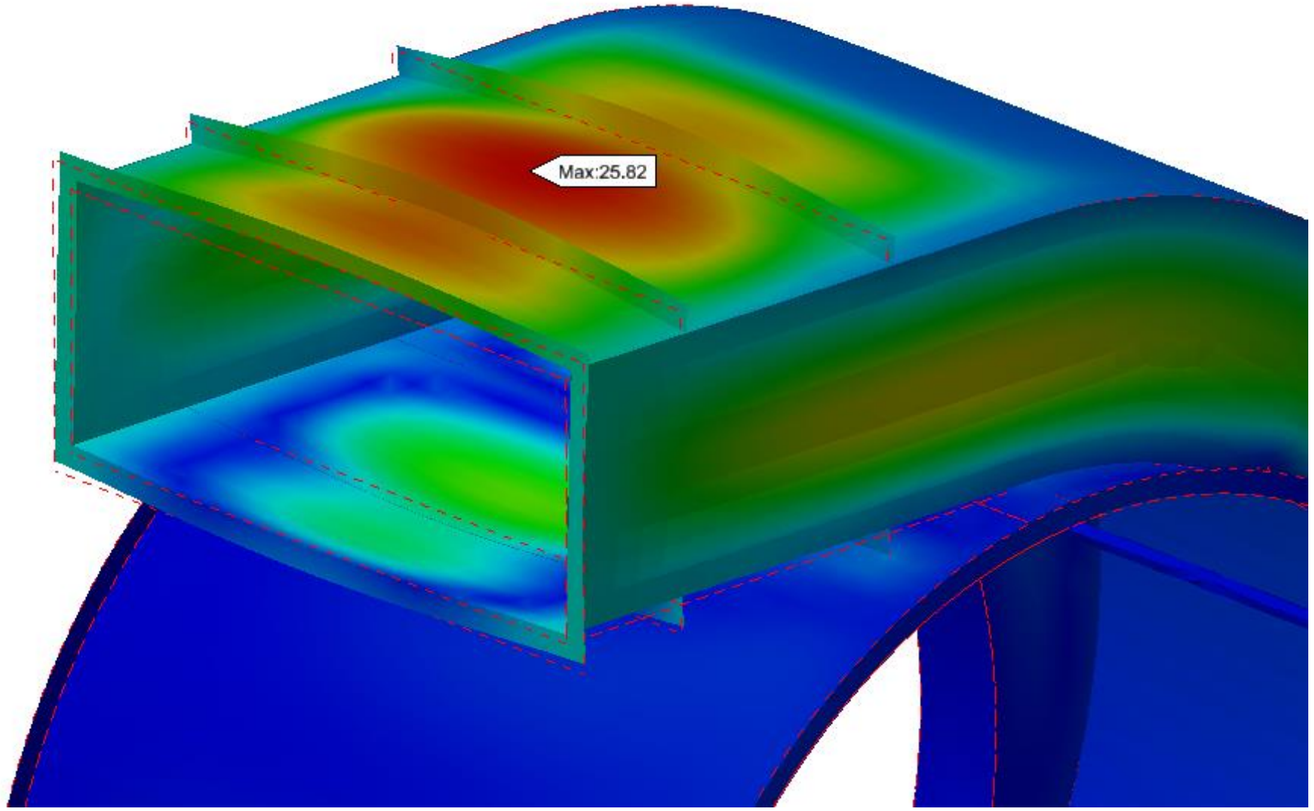


Simatek A/S

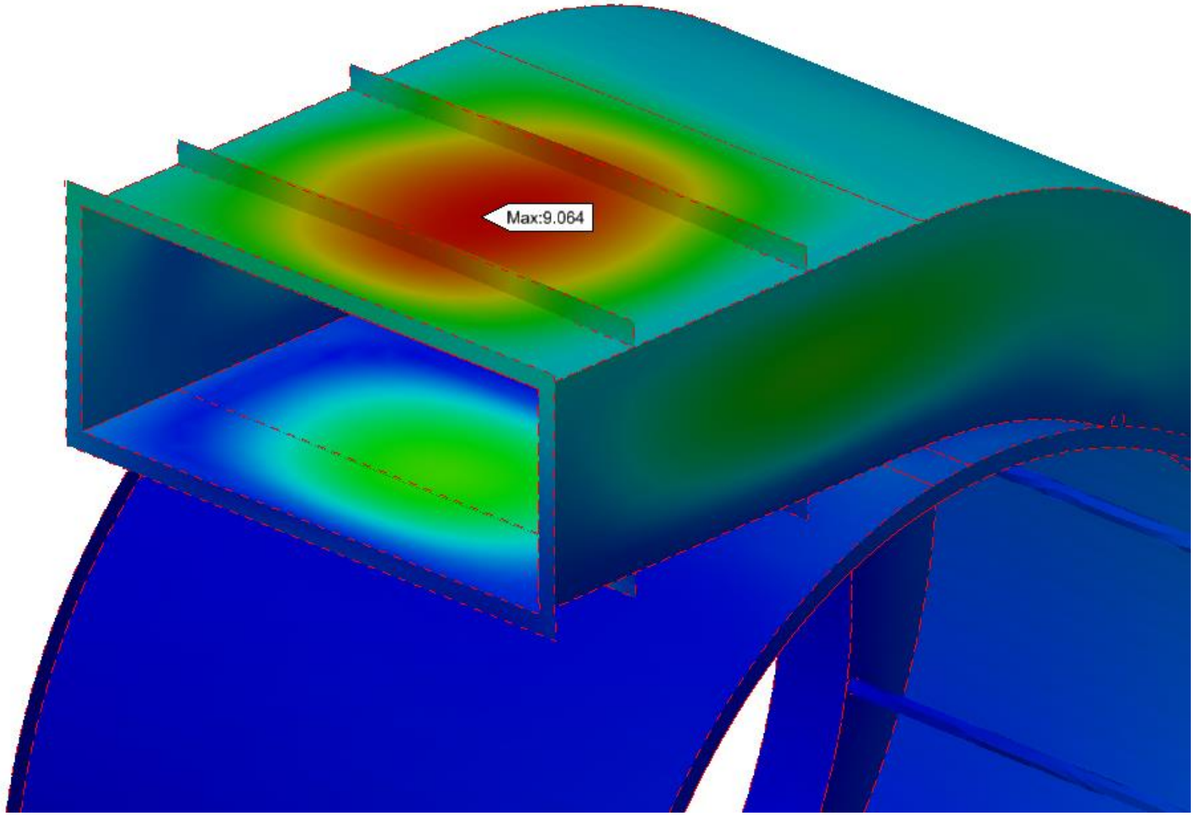

Nonlinear Material Data
Type
None
Nonlinear Elastic
Elasto-Plastic (Bi-Linear)
Plastic
σ
Yi
E
ε
Strain
Stress (MPa)
0
0
0.001084210526
206
0.0015
216.2
0.002
230
0.01
260
0.45
540
Properties
Tangent Modulus, Et (MPa):
19000
Hardening Rule:
Isotropic
Yield Function
Yield Criterion:
von Mises
Initial Yield Stress (MPa):
206
Friction Angle: (deg):
0
Show XY Plot
XY Plot
Curve Options
Type:
Line
Step:
None
Spline
Fill Area
Log Y
Log X
Curve Display
Color:
Choose Color
Style:
Solid
Width:
0
Vertical Bar Width:
10 %
Copy Data to Clipboard
Show Grid
Default Settings
Set As Default Settings
OK
Stress (MPa) Vs Strain
Stress (MPa)
Strain
0
0.1
0.2
0.3
0.4
0.5
600
500
400
300
200
100
0

Simatek A/S

Deformation Under Loading



Permanent Deformation When Unloaded



CUE DEE (Frequency Response)

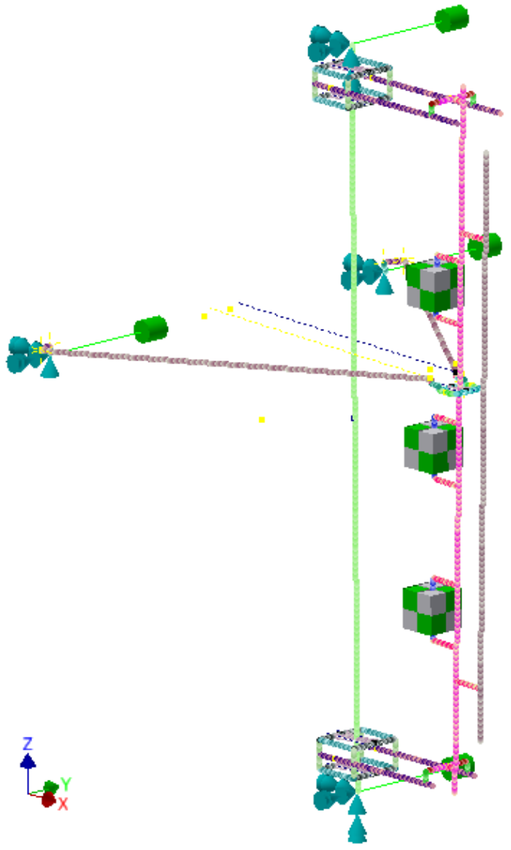
Goal: Is to verify structural integrity from vibration/shaking loading

Design Criteria:

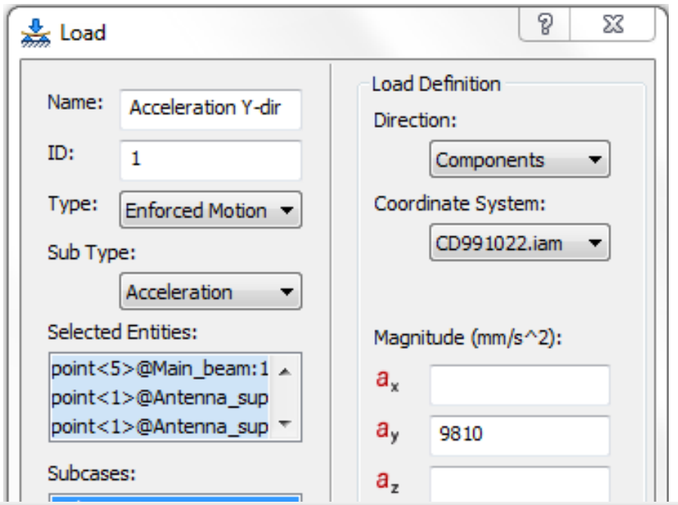
- Predefined displacements/acceleration within a specific frequency interval (according to standard testing procedures)
  - 2-9Hz: 3mm displacements
  - 9-200Hz: 1g acceleration
  - All directions

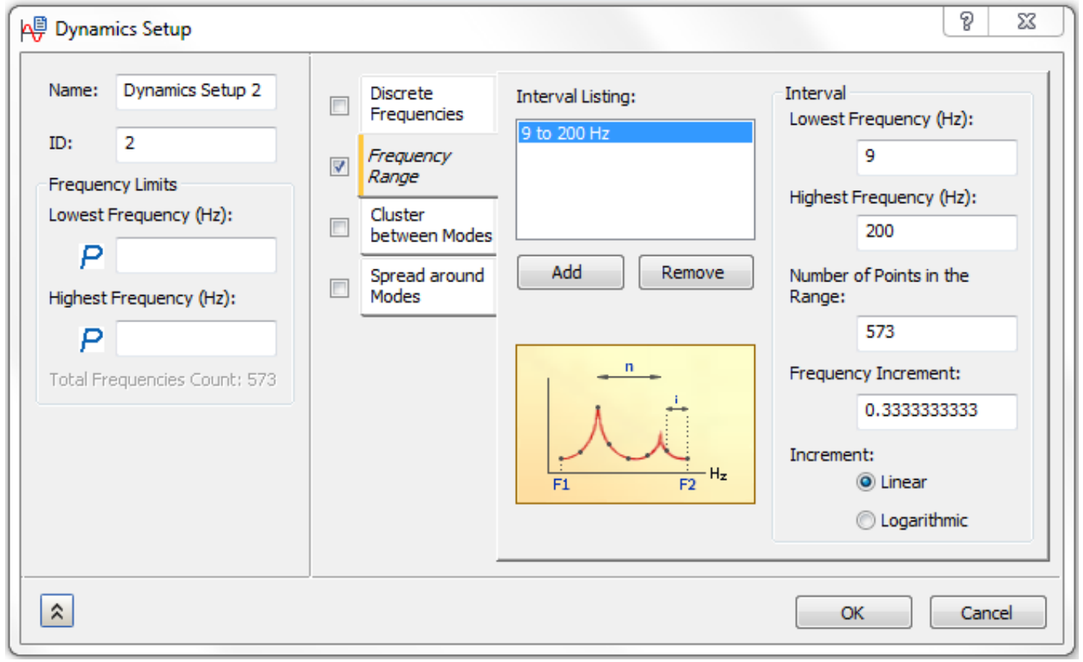
CUE DEE

Beam Elements



3D Visualisation





CUE DEE

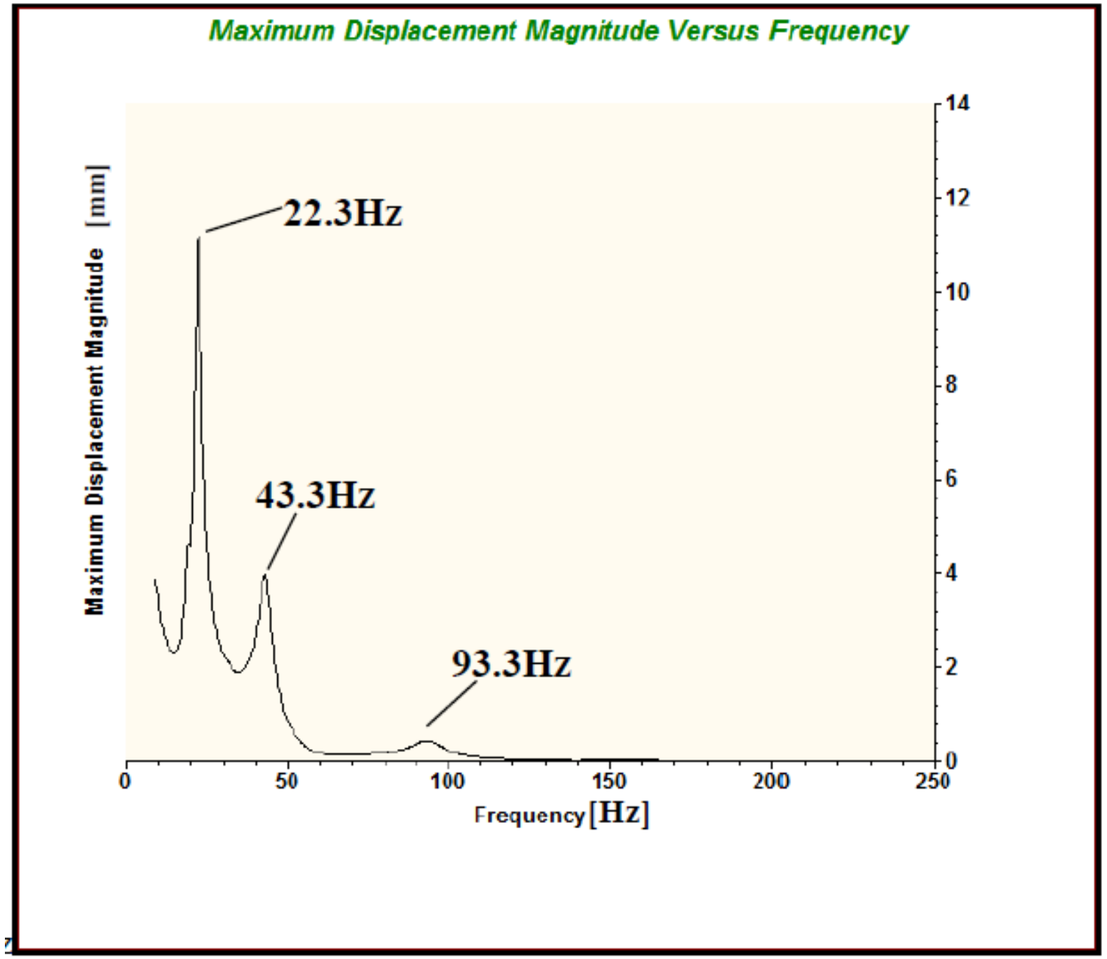
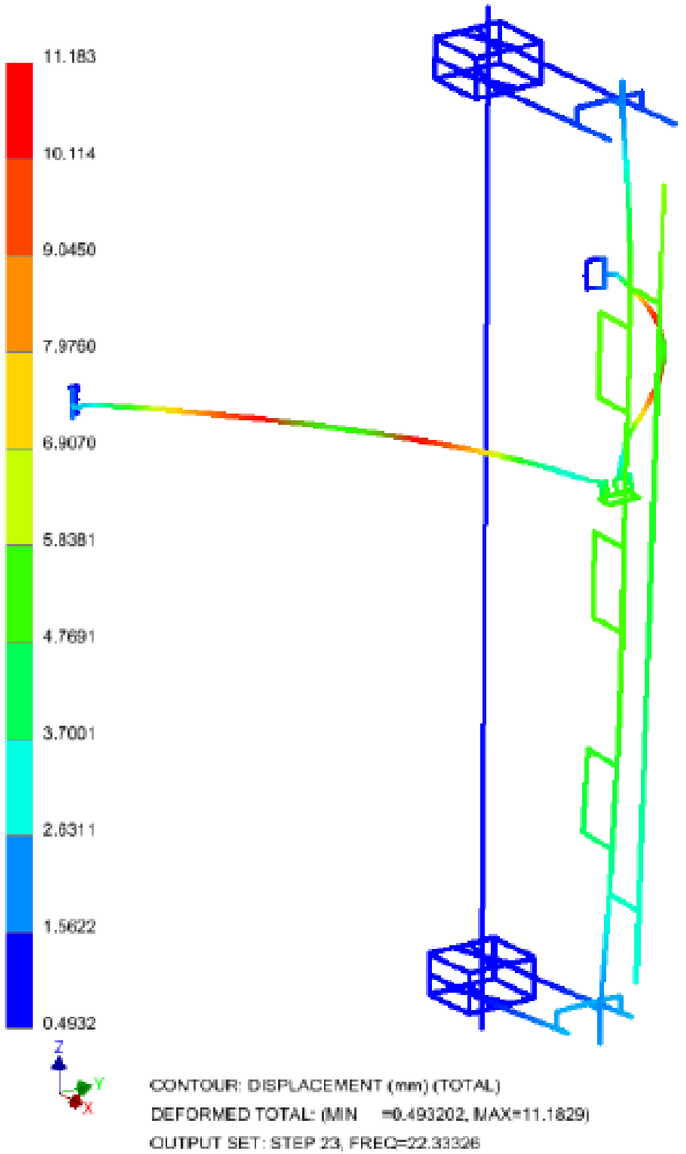
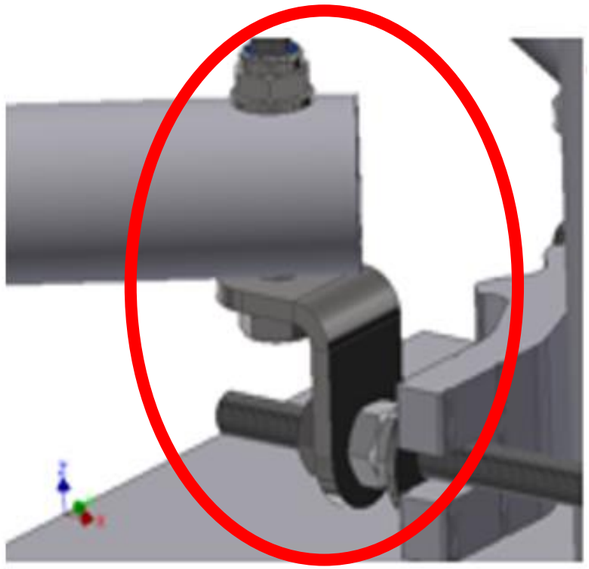
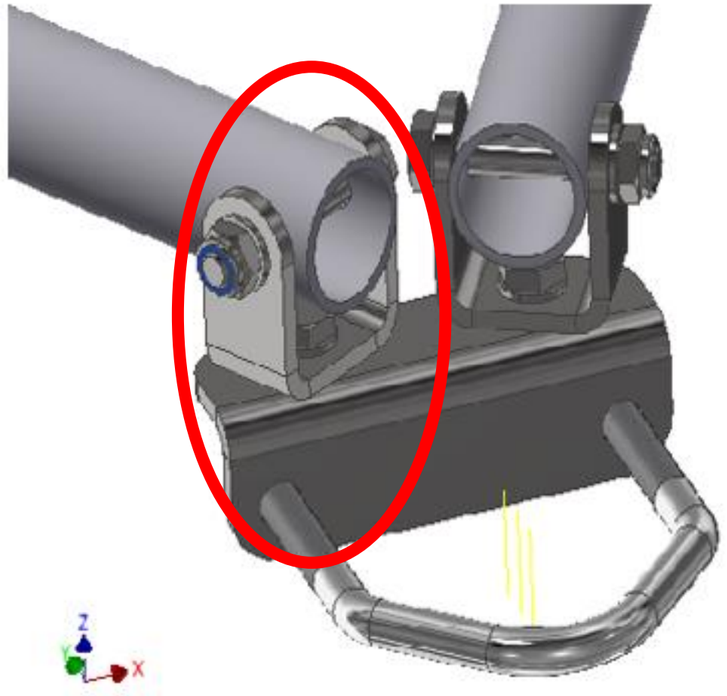


Figure 7 Max displacement vs frequency, x-direction.

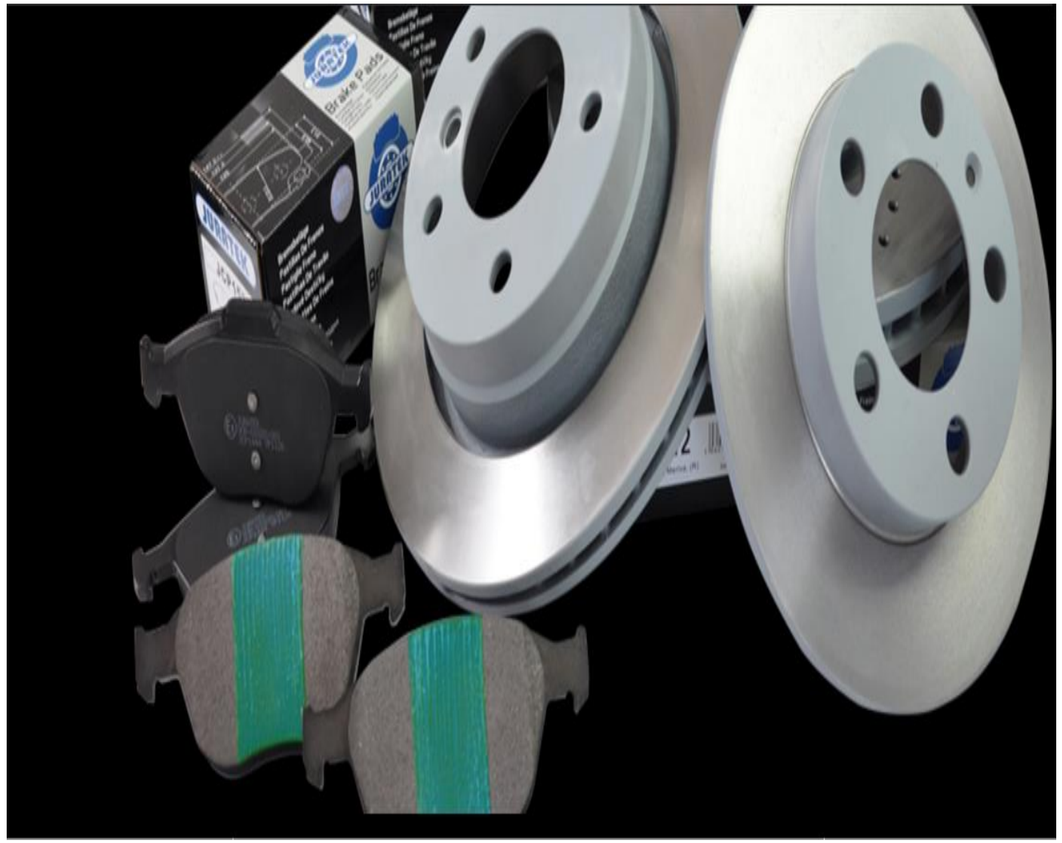


CUE DEE

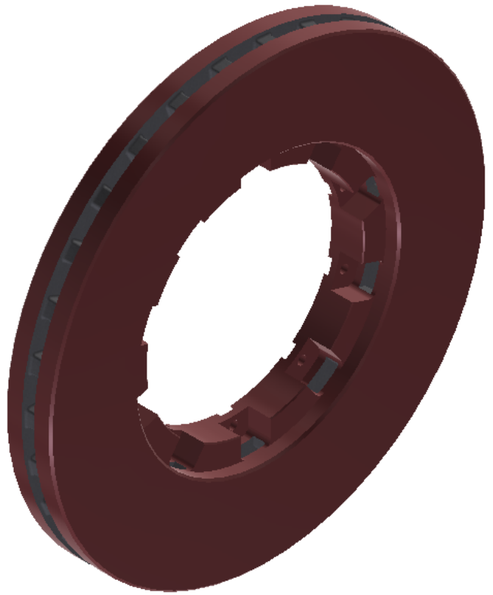




Juratek (Thermal Stress)



Goal: Is to determine stresses due to braking

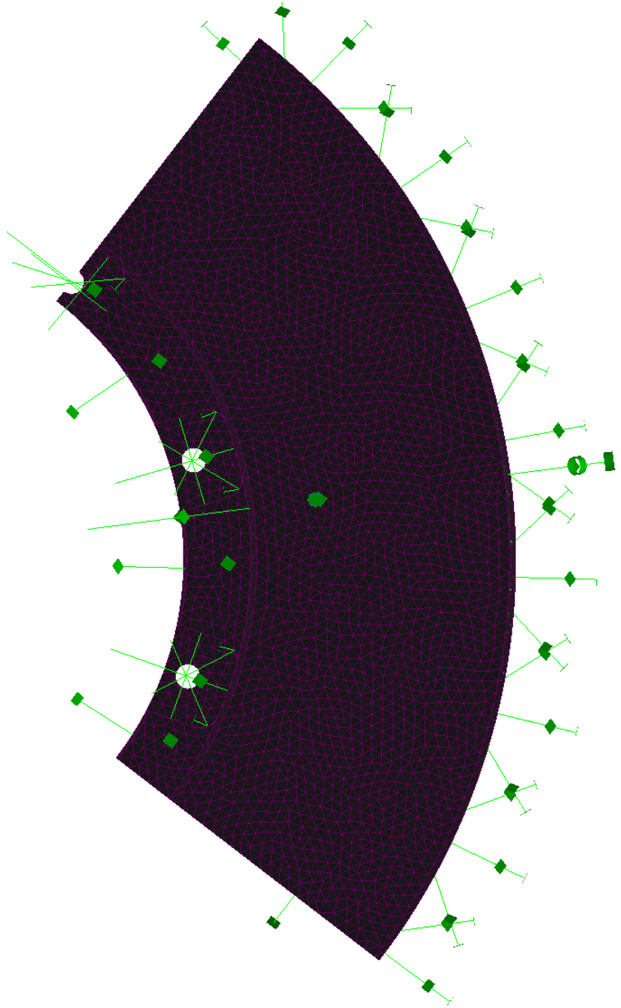


Design Criteria:

- Stress is below yield limit

Juratek

- Part
  - Analysis 1 [Nonlinear Transient Heat Transfer]
    - Units : CAD Model
    - Nodes 325766
    - Elements 227050
    - Part 1
    - Idealizations
      - Solids
        - Solid 1
    - Mesh Model
    - Subcases
      - Subcase 1
        - Loads
          - Heat Flux
          - Convection
          - Radiation
          - Initial Temp
        - Constraints
        - Time Step 1
        - Results
  - Analysis 1 - Copy [Linear Static]
- Model
- Parameters
- Coordinate Systems



Time Step

Name: Time Step 1

ID: 1

Interval Listing:

0 to 4.5 s

Add | Remove

Solution Settings

Step Method: ADAPTIVE

Interval Setup

Cycle Dependent: Duration (s)

Time Step (s): 0.5

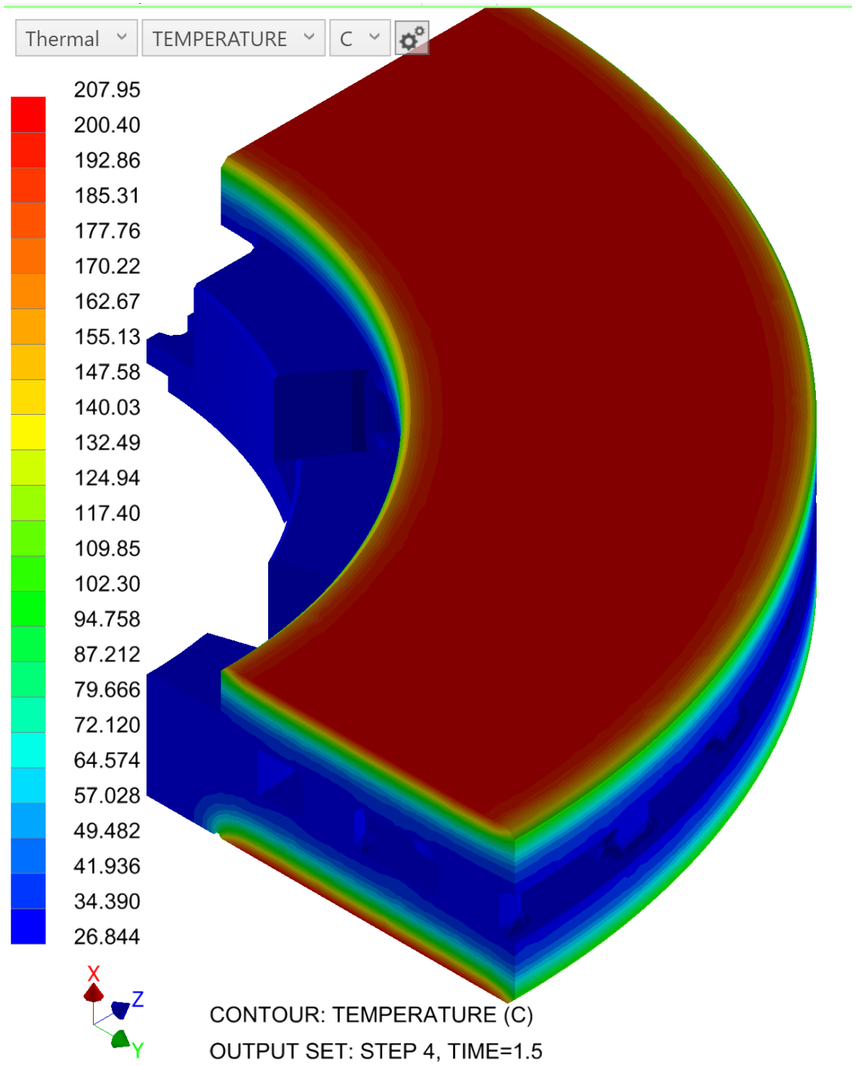
Number of Timesteps: 9

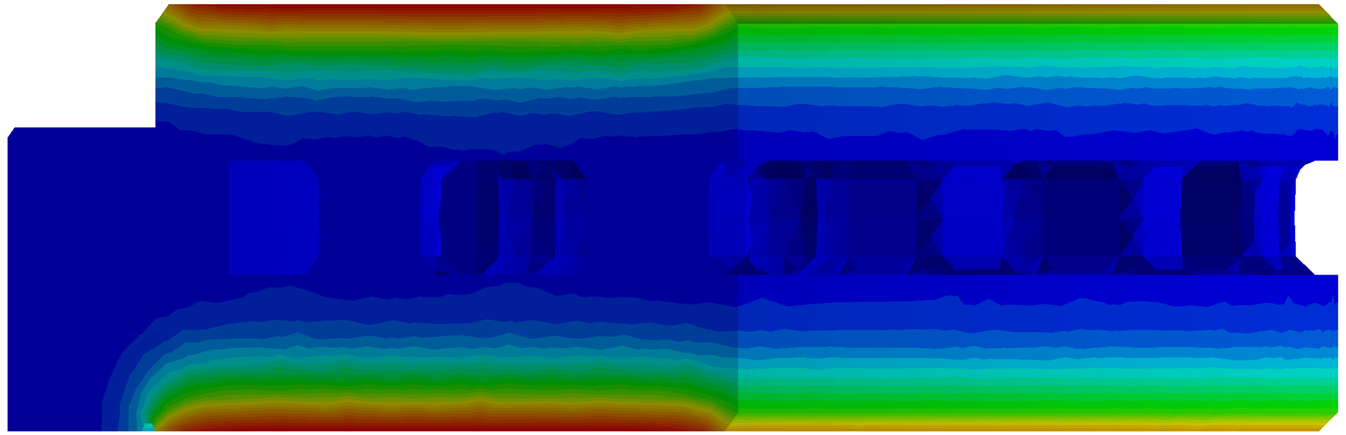
Duration (s): 4.5

Skip Factor (for output): 1

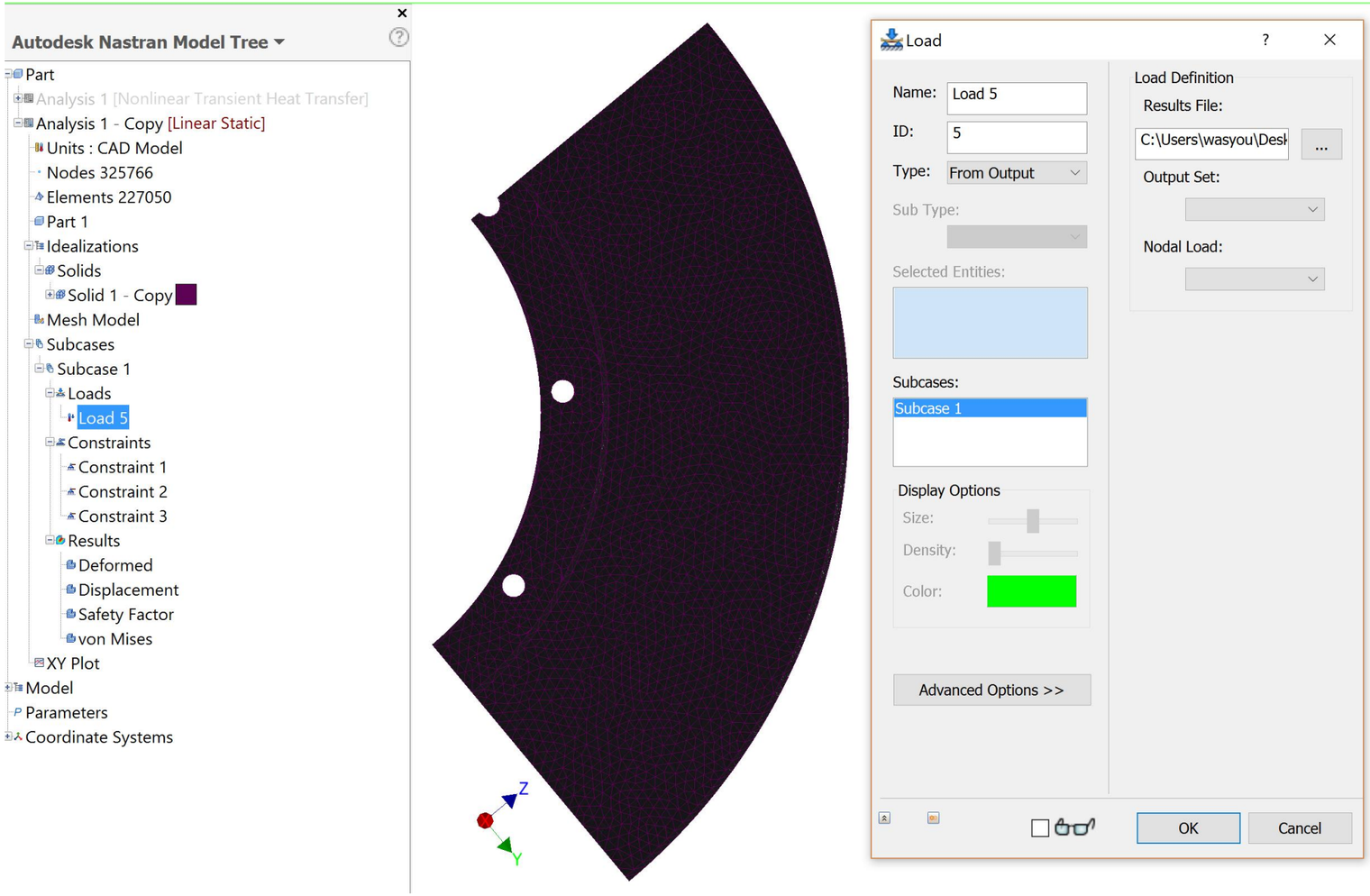
OK | Cancel

Juratek

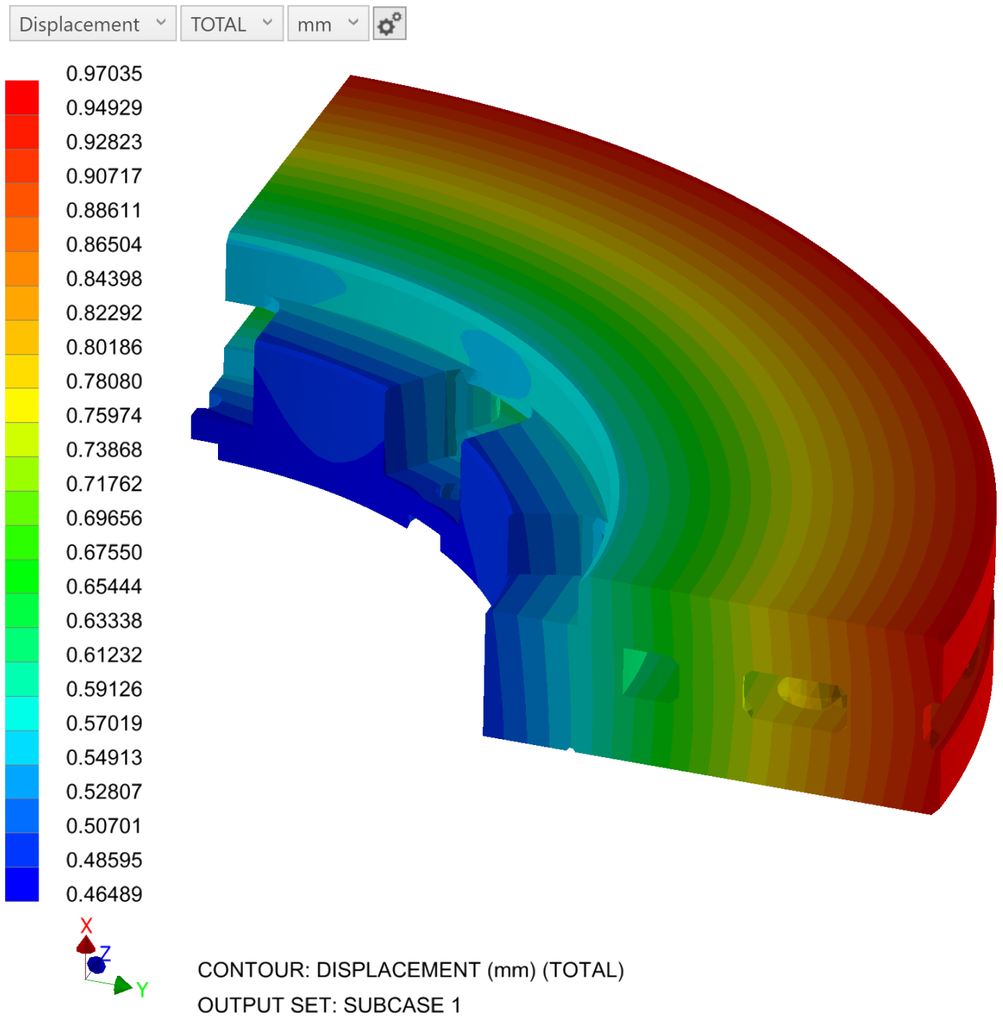

Thermal
TEMPERATURE
C
207.95
200.40
192.86
185.31
177.76
170.22
162.67
155.13
147.58
140.03
132.49
124.94
117.40
109.85
102.30
94.758
87.212
79.666
72.120
64.574
57.028
49.482
41.936
34.390
26.844
X
Z
Y
CONTOUR: TEMPERATURE (C)
OUTPUT SET: STEP 4, TIME=1.5



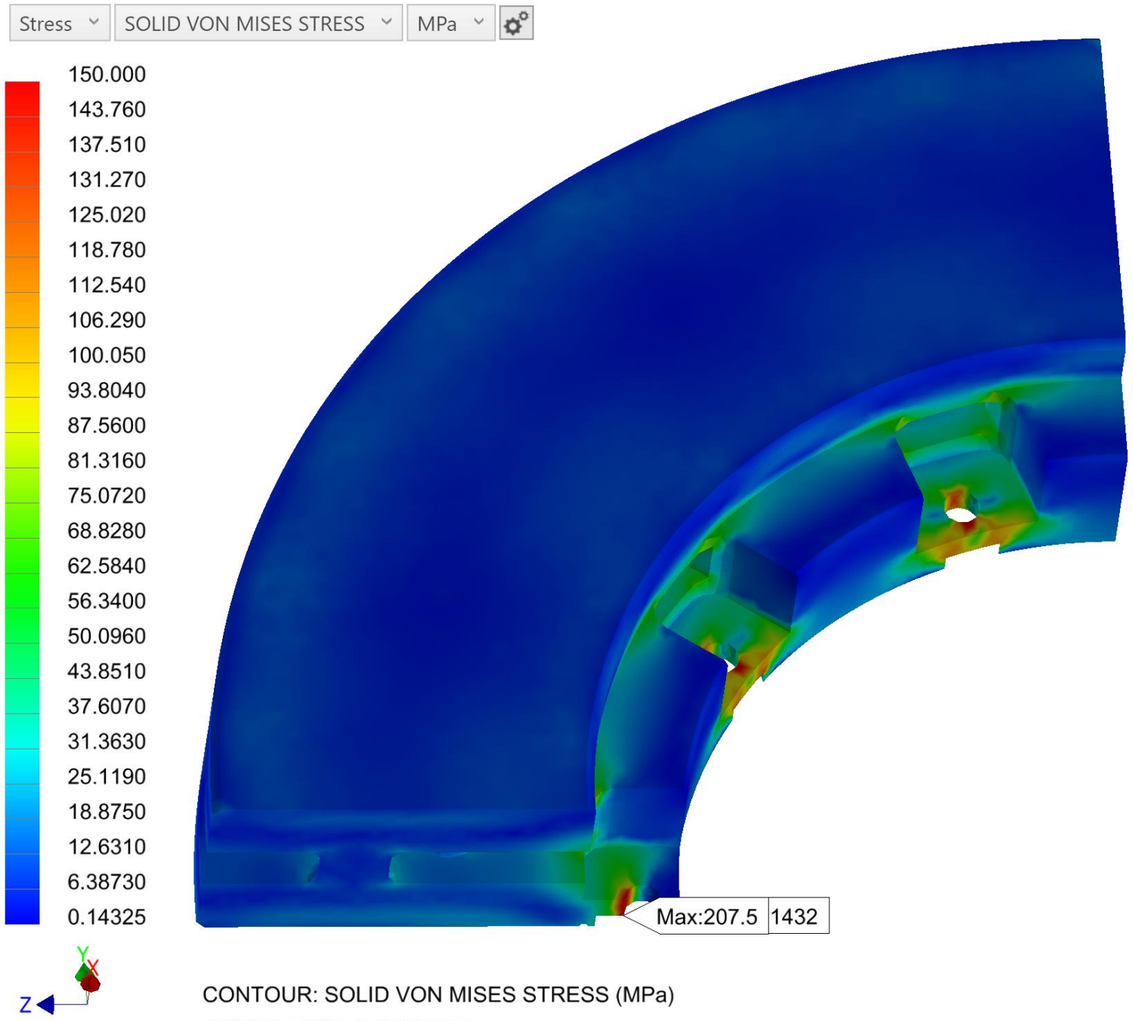
Juratek


Autodesk Nastran Model Tree
Part
Analysis 1 [Nonlinear Transient Heat Transfer]
Analysis 1 - Copy [Linear Static]
Units : CAD Model
Nodes 325766
Elements 227050
Part 1
Idealizations
Solids
Solid 1 - Copy
Mesh Model
Subcases
Subcase 1
Loads
Load 5
Constraints
Constraint 1
Constraint 2
Constraint 3
Results
Deformed
Displacement
Safety Factor
von Mises
XY Plot
Model
Parameters
Coordinate Systems
Z
Y
Load
Name:
Load 5
ID:
5
Type:
From Output
Sub Type:
Selected Entities:
Subcases:
Subcase 1
Display Options
Size:
Density:
Color:
Advanced Options >>
Load Definition
Results File:
C:\Users\wasyou\Desk
...
Output Set:
Nodal Load:
OK
Cancel

Juratek



CONTOUR: DISPLACEMENT (mm) (TOTAL)
OUTPUT SET: SUBCASE 1



CONTOUR: SOLID VON MISES STRESS (MPa)
OUTPUT SET: SUBCASE 1

Questions

Additional resources

Inventor

- Self paced learning books
- Training Courses

Nastran

- Self paced learning books
- Training Courses

AUTODESK®

Make anything.