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ENR501474 | Nonlinear Static Simulation of an Oil and Gas Multicontact Seal Application

Wednesday September 28th 11:30 am

Arne Kjaer

CEO – Owner | PTFE Engineering A/S | LinkedIn

David Weinberg

Distinguished Research Scientist | Autodesk, Inc. | LinkedIn

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Arne Kjaer
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David Weinberg
Distinguished Research Scientist | Autodesk, Inc. | LinkedIn

Arne Kjaer
CEO / owner @ PTFE Engineering

- Polymer Specialist and Mechanical Engineer from the Technical University of Denmark
- 39 years of experience in development of material compositions and processing within the PTFE industry
- First FEA material model work in 1992 with the University of Stuttgart
- Polymeric Materials Modeling for 6 years with, Autodesk Nastran, LS Dyna, COMSOL and ANSYS.
- Meet David first time at AU 2015 in Las Vegas

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David Weinberg

- Distinguished Research Scientist with Autodesk
- Autodesk Product Development and Manufacturing Solutions (PDMS), Nastran Simulation and Generative Design group
- Primary developer for Autodesk Nastran and Inventor Nastran
- Currently lead the team of developers for Autodesk Nastran
- Over 35 years’ experience in FEA simulation working both as a user for several large Aerospace companies and as a developer
- Retired USAF aircraft commander/pilot

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AU presentations by

- David and Arne

AU 2018 – Las Vegas

- *Challenges of Simulating Advanced Materials in Nonlinear Applications*

AU 2019 – Las Vegas

- *Simulating with Nonlinear Materials like Hyperelastic and Isotropic Polymer Material*

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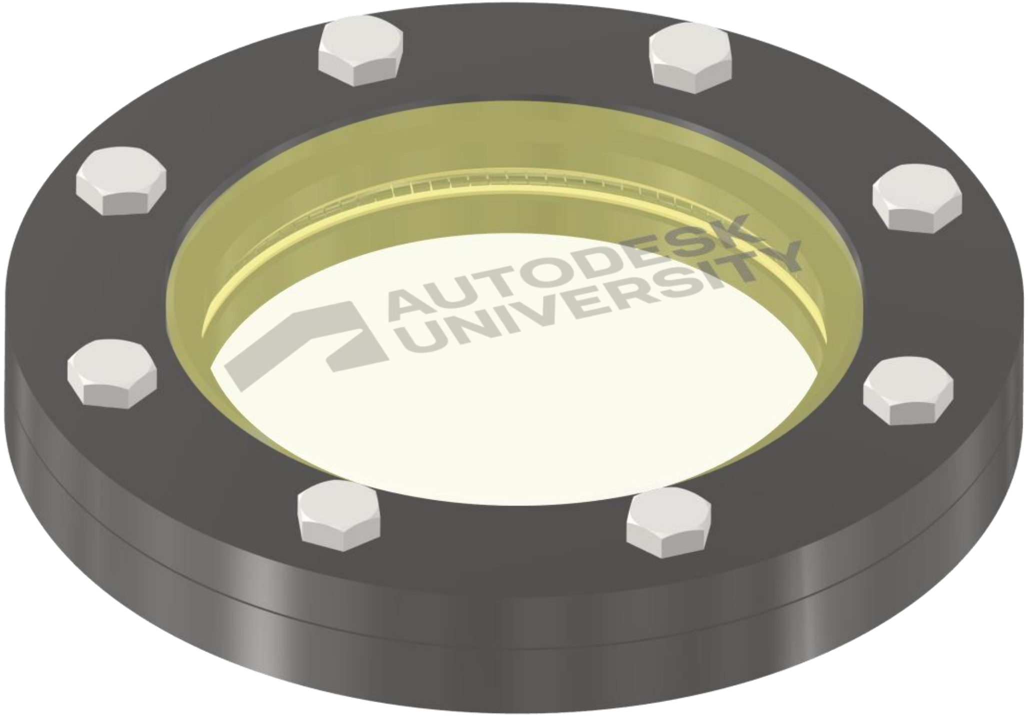
Learning Objectives.

- Prepare the Inventor Assembly to the Nastran Simulation.
- Setup of a Nonlinear Static Nastran Analysis from an Inventor Assembly.
- Using Material Model Data from Customer Material Measurements.
- Using multiple Subcases using same constrains and loads.
- Setup of Enforced Motion, Surface Pressure.
- Optimize the Mesh and Mesh Control to get reliable results in less time.
- Special Parameters setting to help the Analysis Running.
- Looking at the Results

Case Story

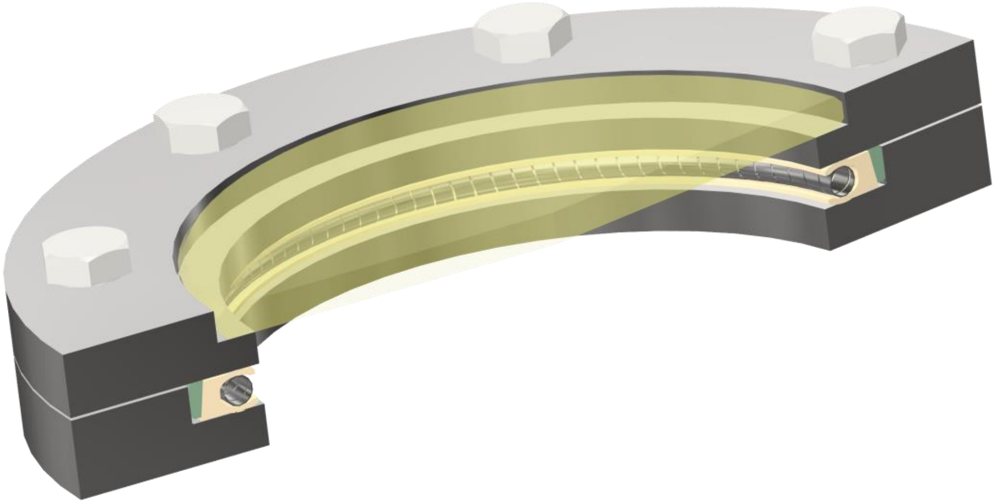


An Inspection Hatch in a Machinery with high Pressure and elevated Temperature need to be sealed of so the inside substance can not escape to the outside.

This Hatch is constructed to be used for this demonstration of Inventor Nastran 2023.

This case is constructed only for the AU 2022 in New Orleans, USA.

Case Story



Cross section of the Hatch showing the Sealing System making a tight assembly between the lid and the groove.

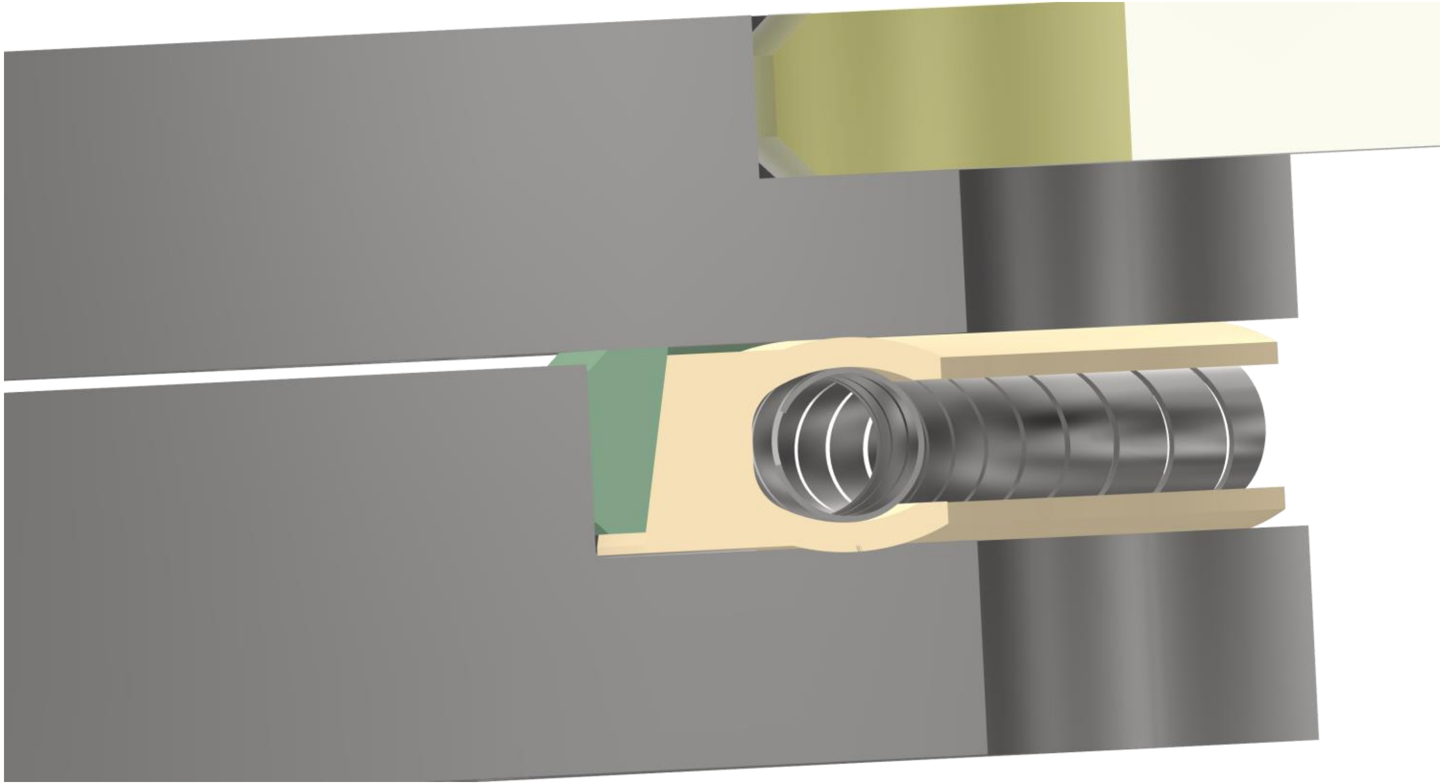
The Seal is a high-pressure Metal Spring Activated Seal supported by a PEEK Back UP Ring to prevent the Seal the escape in the clearance between the groove and the Lid.

Pressure and temperature in such a case will typically be room temperature and compressed air-pressure.

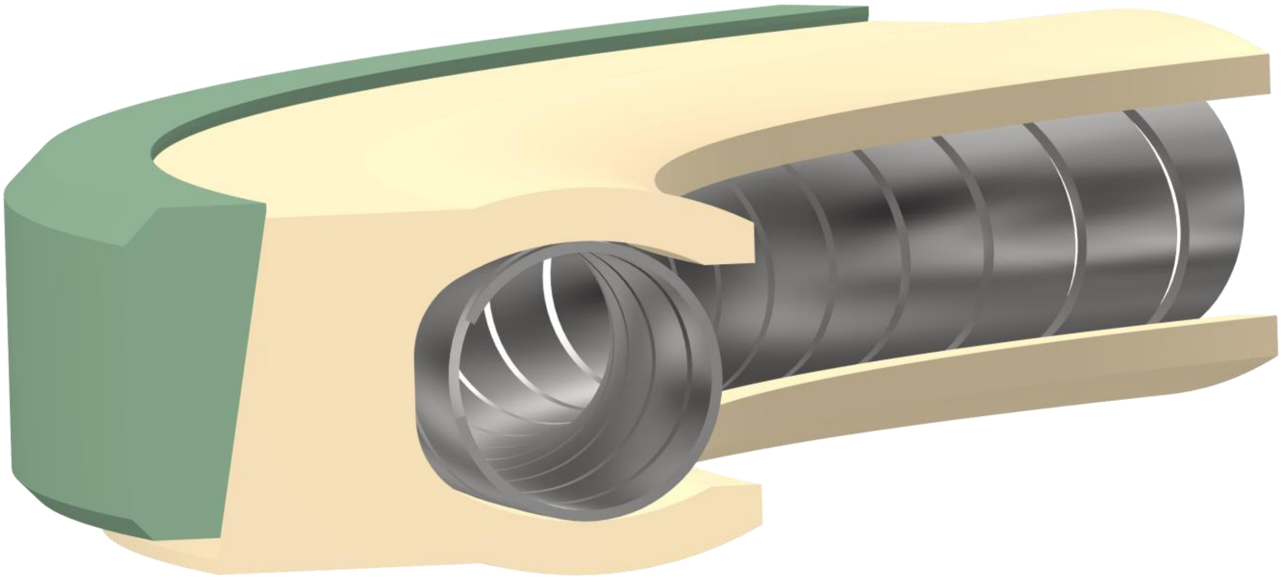
In this case here we calculate with much higher pressure 1450 psi.

Temperature will be calculated at 73°F

Case Story



Case Story

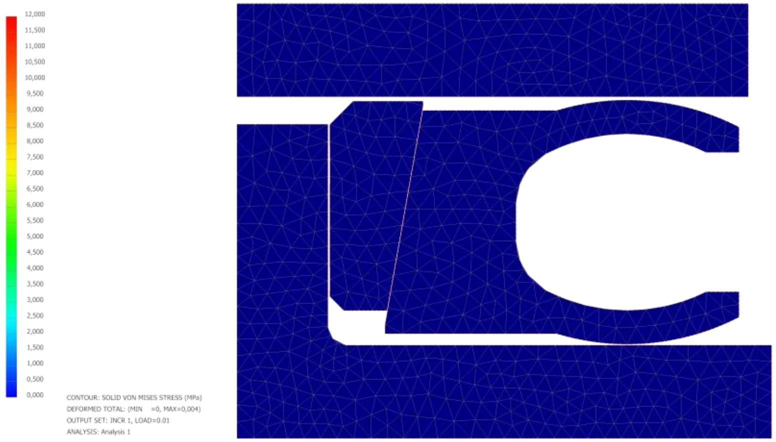


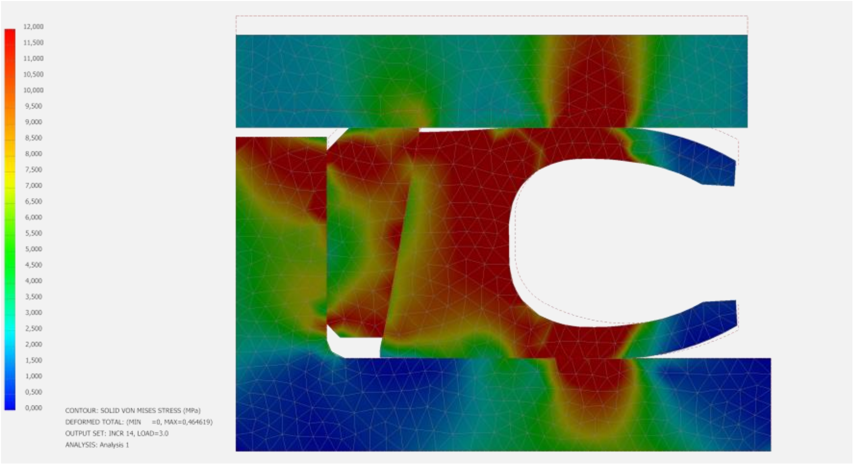
We need to make this Assembly simpler to be able to simulate it.

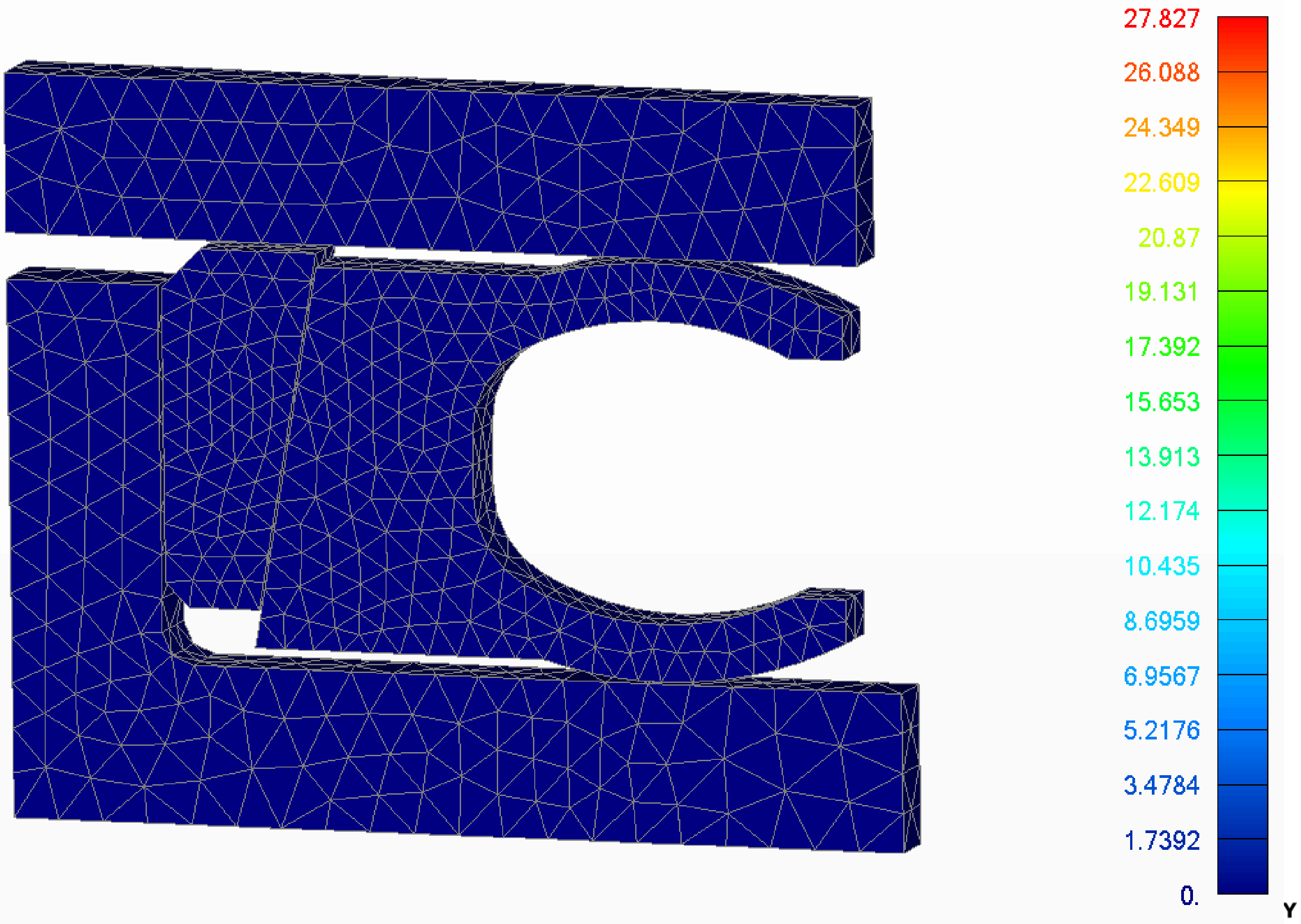
The Metal Spring has to be exchanged by a spring force or a surface pressure.

What do we simulate in this class ?

Initial compression of the installed seals, metal spring simulation and high-pressure simulation






27.827
26.088
24.349
22.609
20.87
19.131
17.392
15.653
13.913
12.174
10.435
8.6959
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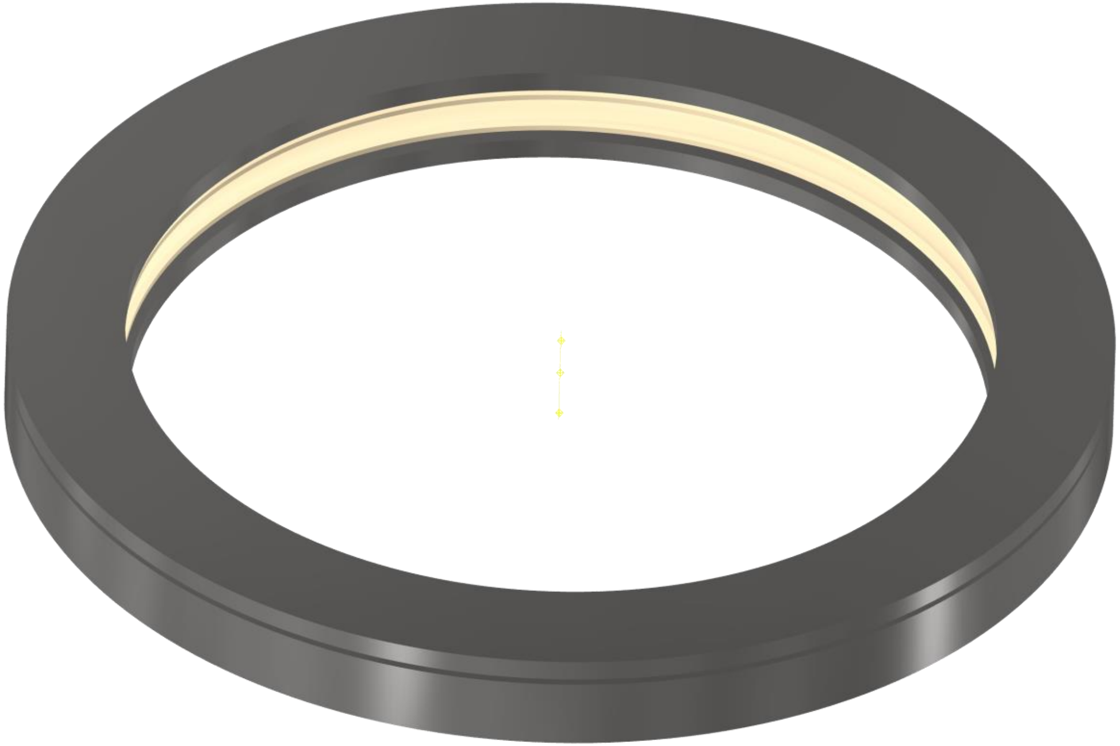
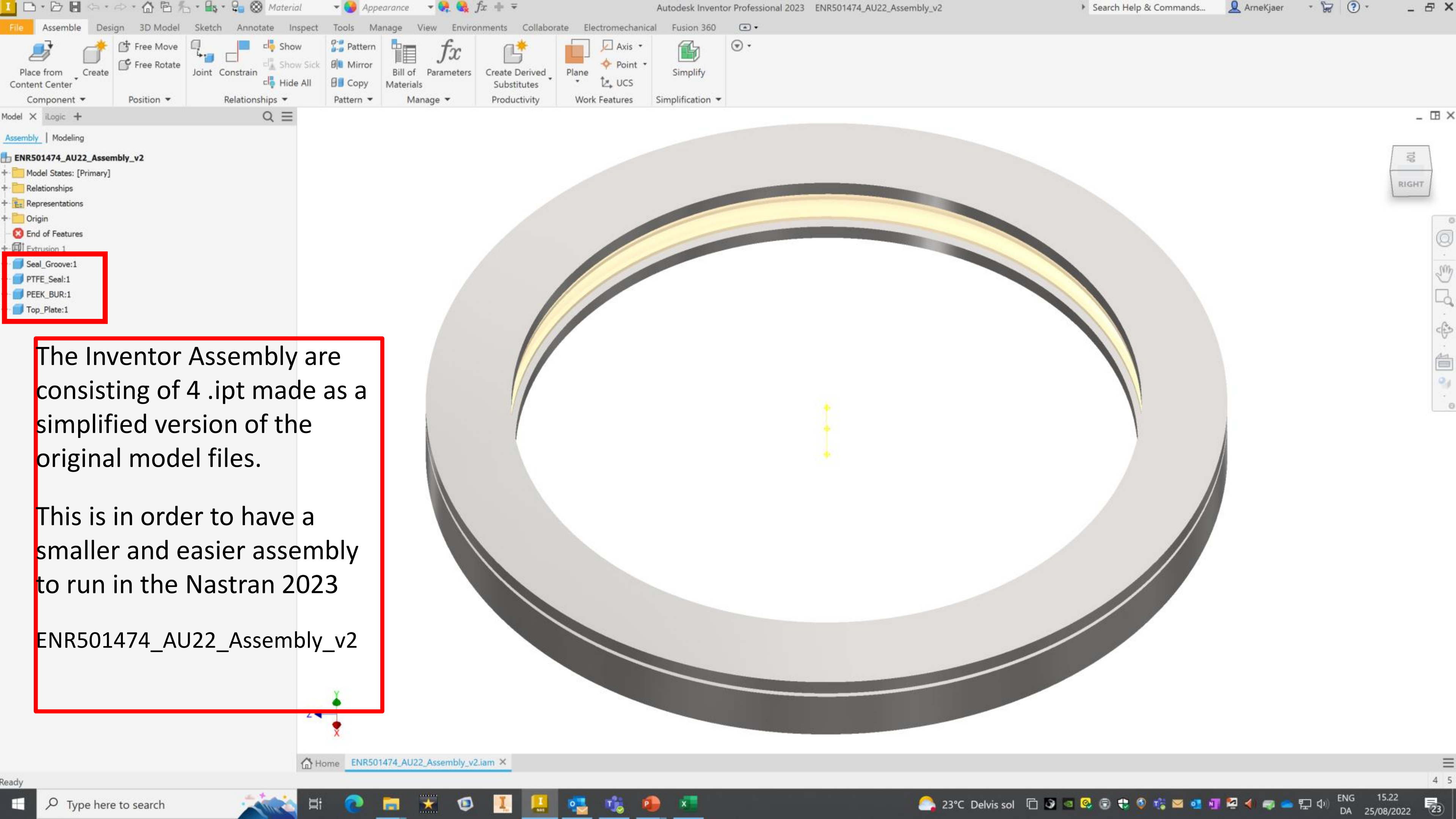
Autodesk Inventor Nastran 2023 Assembly



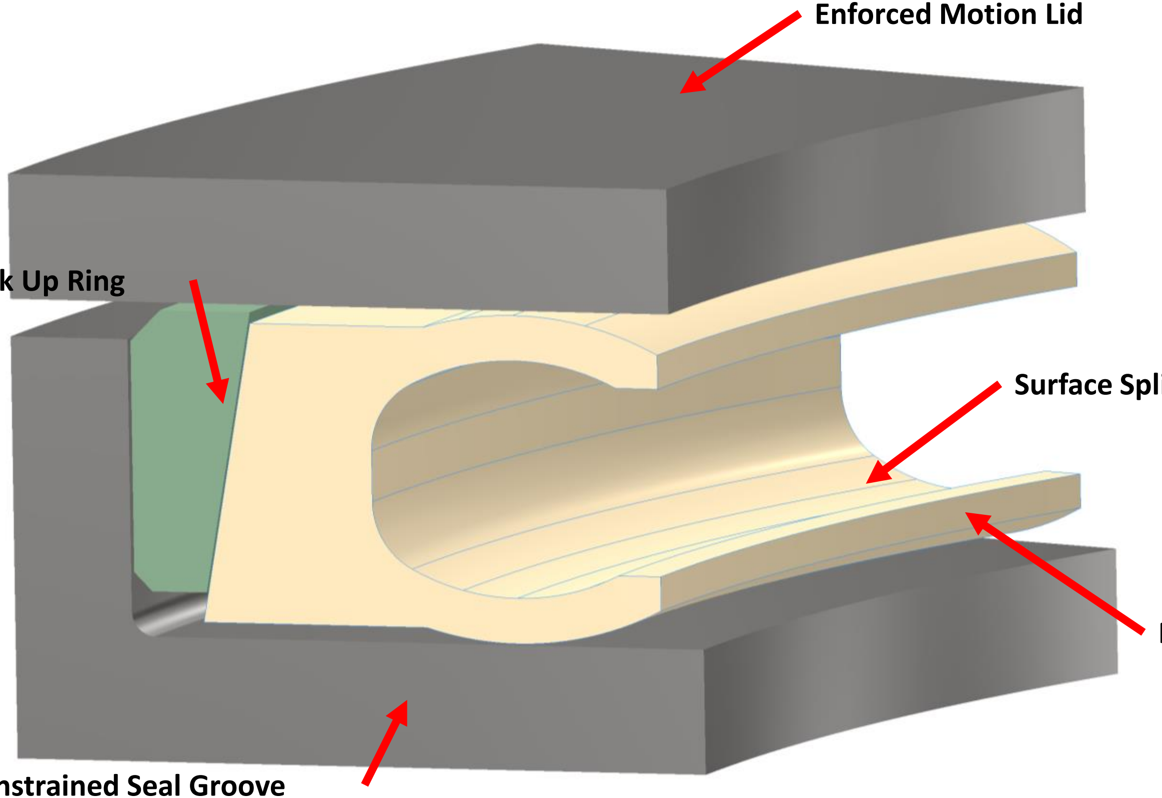


The Inventor Assembly are consisting of 4 .ipt made as a simplified version of the original model files.

This is in order to have a smaller and easier assembly to run in the Nastran 2023

ENR501474_AU22_Assembly_v2

Autodesk Inventor Nastran 2023 Assembly



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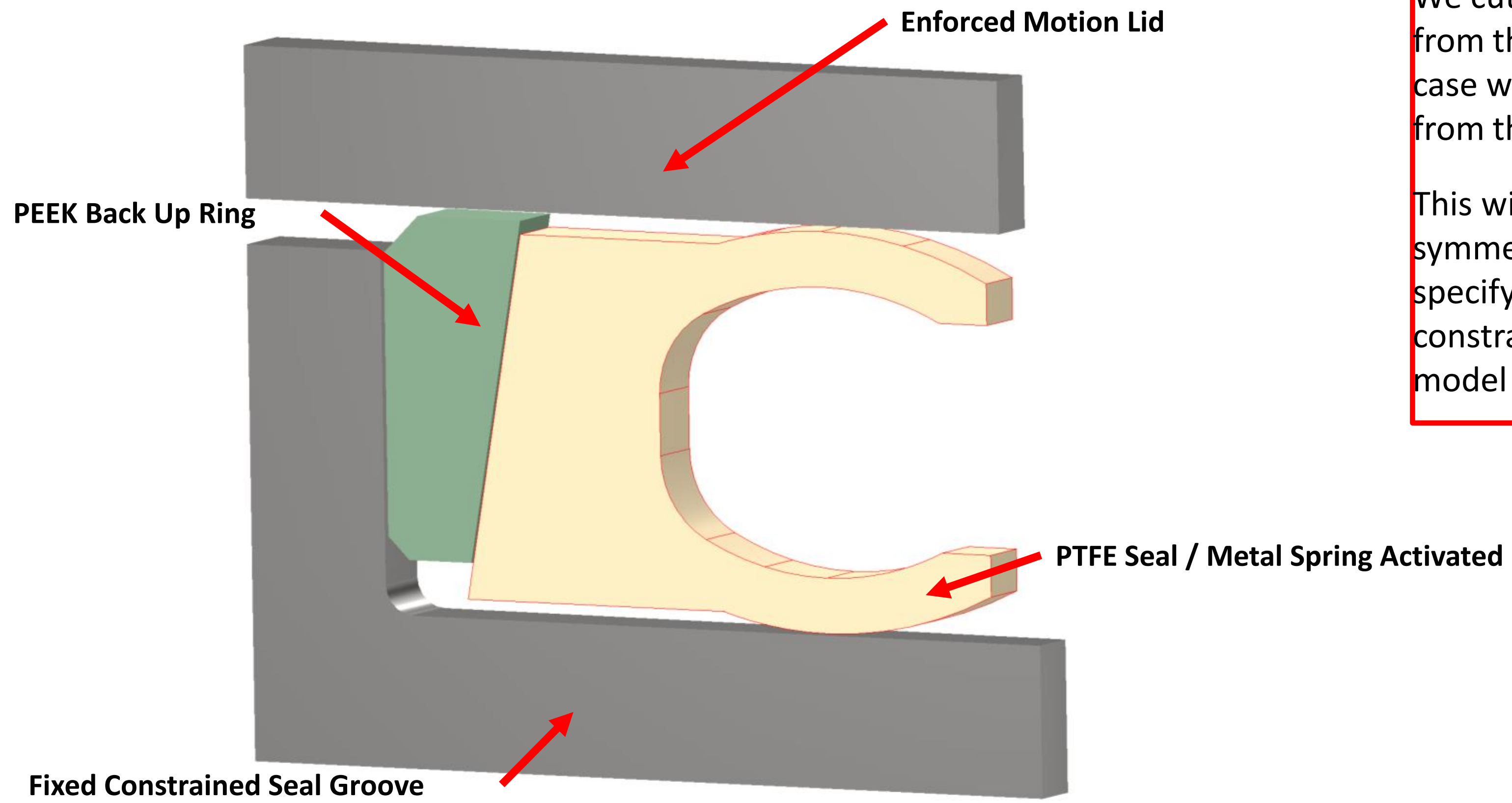
ENR501474_AU22_Assembly_v2

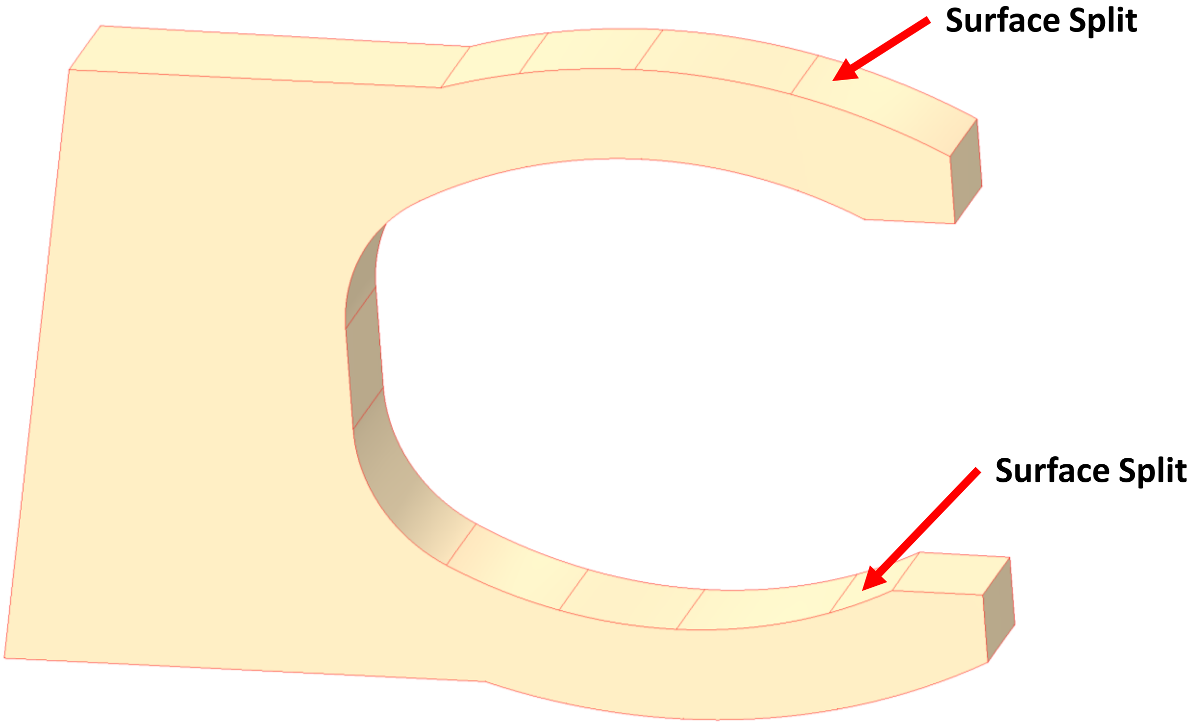
Autodesk Inventor Nastran 2023 Assembly



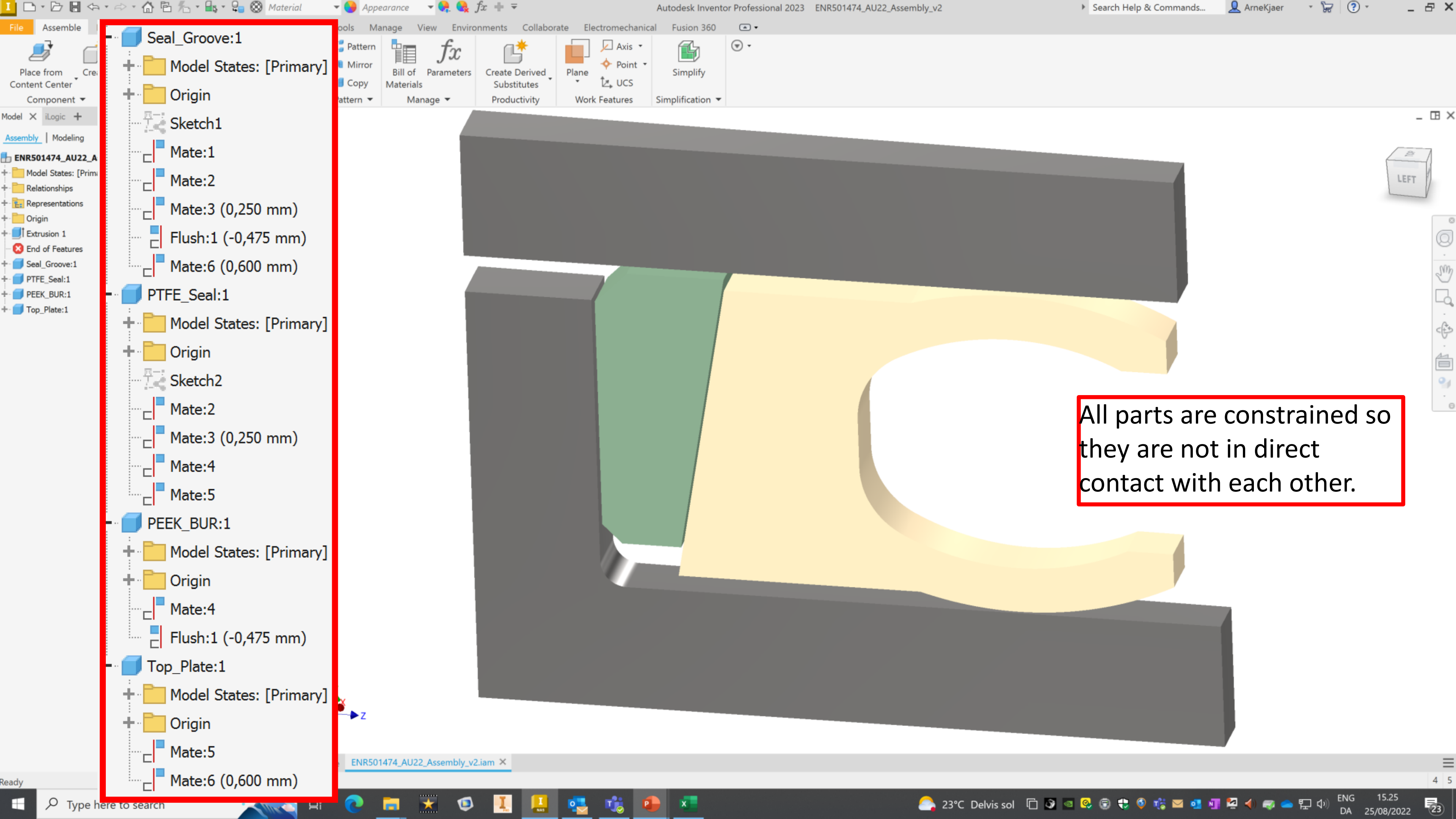
We cut out a smaller slice from the Assembly, in this case we are using ±0,50° from the radial centerline.

This will make the symmetry easier when specifying the symmetry constrain in the simulation model in Nastran 2023

Autodesk Inventor Nastran 2023 Assembly



The Seal has been split into several surfaces in order to apply forces and constrains into smaller parts of surfaces. We will later apply a load on those areas.


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Seal_Groove:1
Model States: [Primary]
Origin
Sketch1
Mate:1
Mate:2
Mate:3 (0,250 mm)
Flush:1 (-0,475 mm)
Mate:6 (0,600 mm)
PTFE_Seal:1
Model States: [Primary]
Origin
Sketch2
Mate:2
Mate:3 (0,250 mm)
Mate:4
Mate:5
PEEK_BUR:1
Model States: [Primary]
Origin
Mate:4
Flush:1 (-0,475 mm)
Top_Plate:1
Model States: [Primary]
Origin
Mate:5
Mate:6 (0,600 mm)
All parts are constrained so they are not in direct contact with each other.
ENR501474_AU22_Assembly_v2.iam

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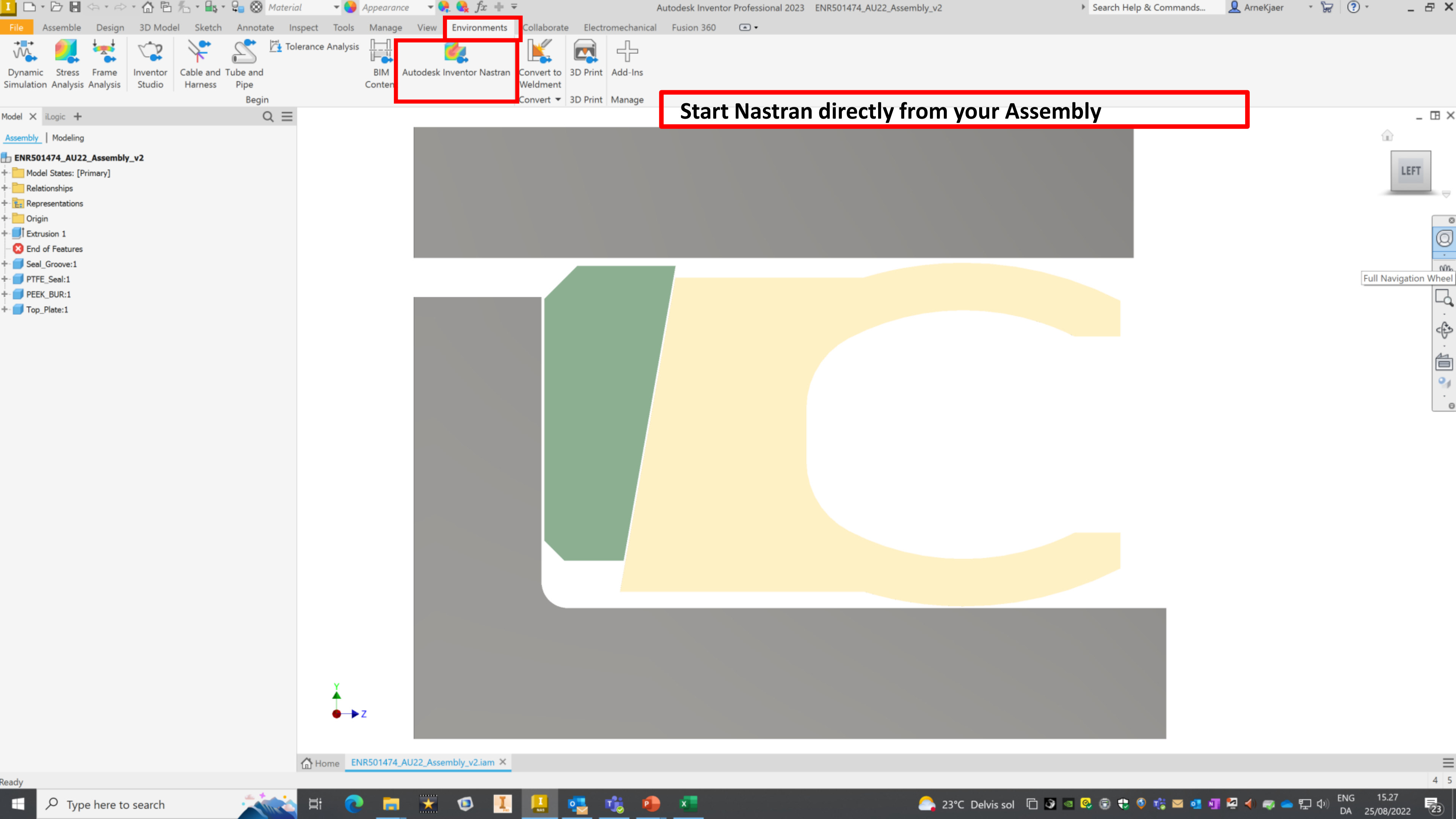
Analysis Method
Coordinate System
Material Set Up


Start Nastran directly from your Assembly
Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Dynamic Simulation
Stress Analysis
Frame Analysis
Inventor Studio
Cable and Harness
Tube and Pipe
Tolerance Analysis
Autodesk Inventor Nastran
Convert to Weldment
3D Print
Add-Ins
Begin
Convert
Manage
Model
iLogic
Assembly
Modeling
ENR501474_AU22_Assembly_v2
Model States: [Primary]
Relationships
Representations
Origin
Extrusion 1
End of Features
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
LEFT
Full Navigation Wheel
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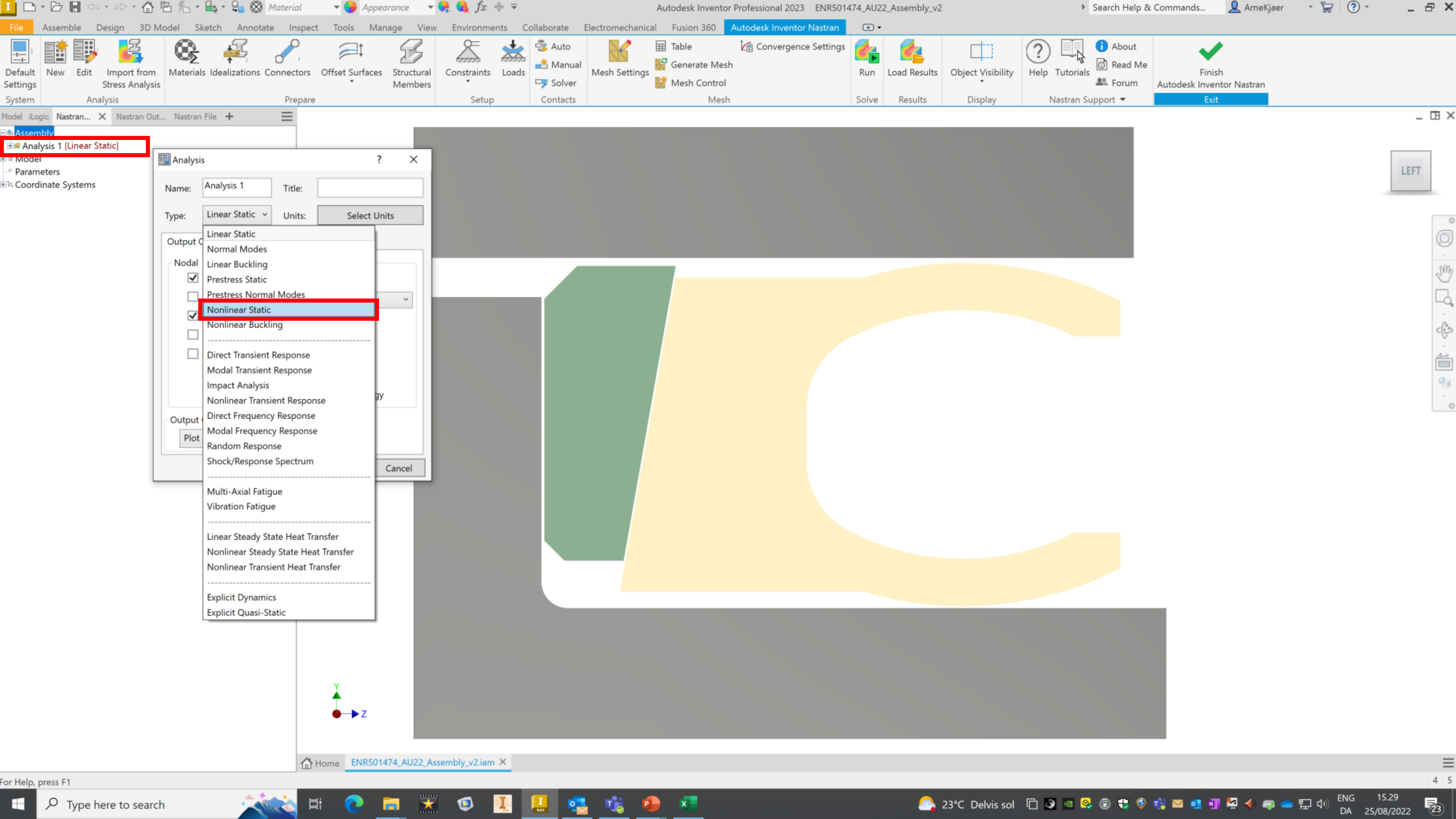
Ready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Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
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Assembly
Analysis 1 [Linear Static]
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Coordinate Systems
Analysis
Name:
Analysis 1
Title:
Type:
Linear Static
Units:
Select Units
Linear Static
Normal Modes
Linear Buckling
Prestress Static
Prestress Normal Modes
Nonlinear Static
Nonlinear Buckling
Direct Transient Response
Modal Transient Response
Impact Analysis
Nonlinear Transient Response
Direct Frequency Response
Modal Frequency Response
Random Response
Shock/Response Spectrum
Multi-Axial Fatigue
Vibration Fatigue
Linear Steady State Heat Transfer
Nonlinear Steady State Heat Transfer
Nonlinear Transient Heat Transfer
Explicit Dynamics
Explicit Quasi-Static
Cancel
LEFT
Home
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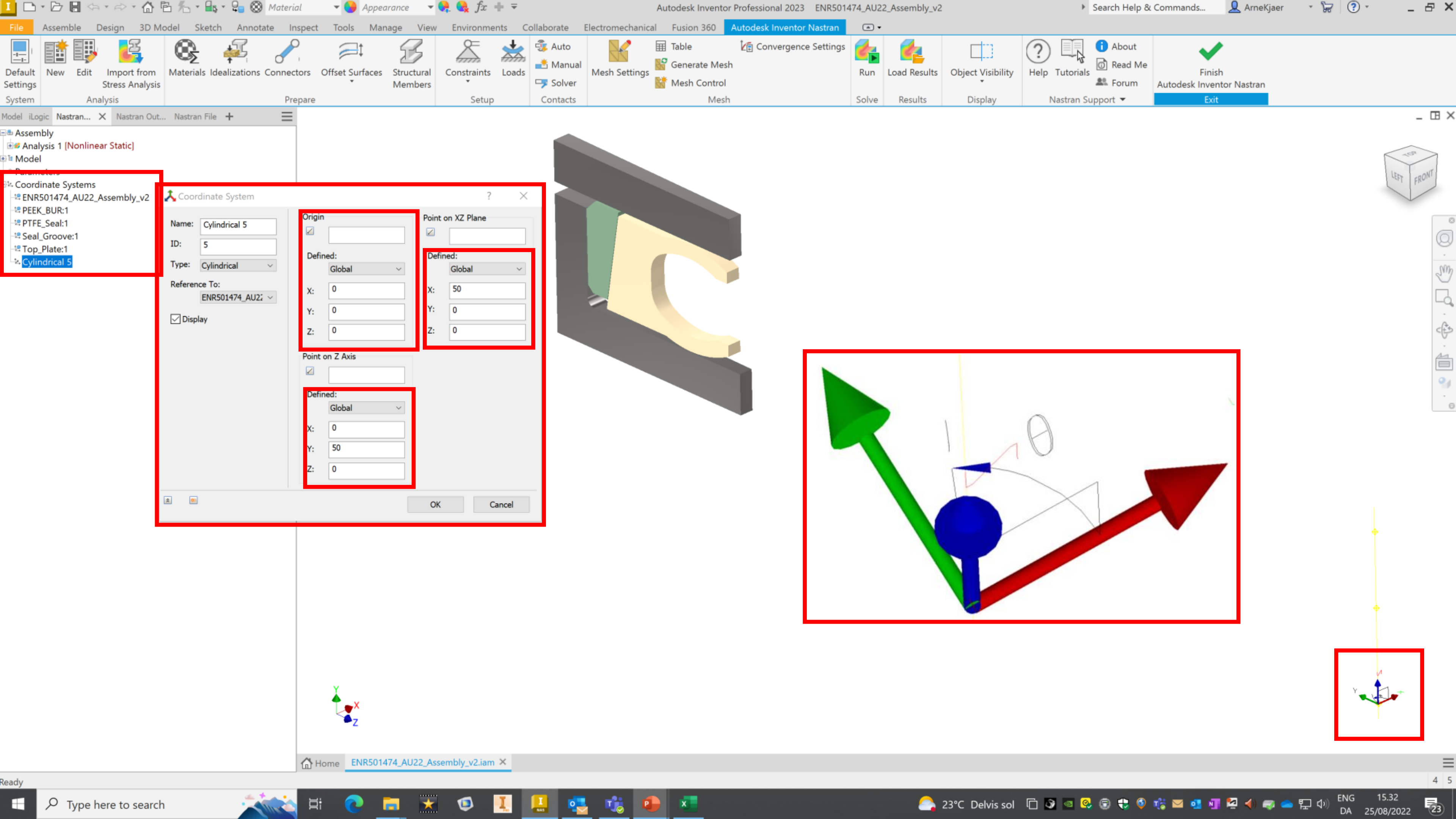
For Help, press F1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Design
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Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
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Nastran Out...
Nastran File
Assembly
Analysis 1 [Nonlinear Static]
Model
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PTFE_Seal:1
Seal_Groove:1
Top_Plate:1
Cylindrical 5
Coordinate System
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ID: 5
Type: Cylindrical
Reference To: ENR501474_AU22
Display
Origin
Defined: Global
X: 0
Y: 0
Z: 0
Point on XZ Plane
Defined: Global
X: 50
Y: 0
Z: 0
Point on Z Axis
Defined: Global
X: 0
Y: 50
Z: 0
OK
Cancel
Home
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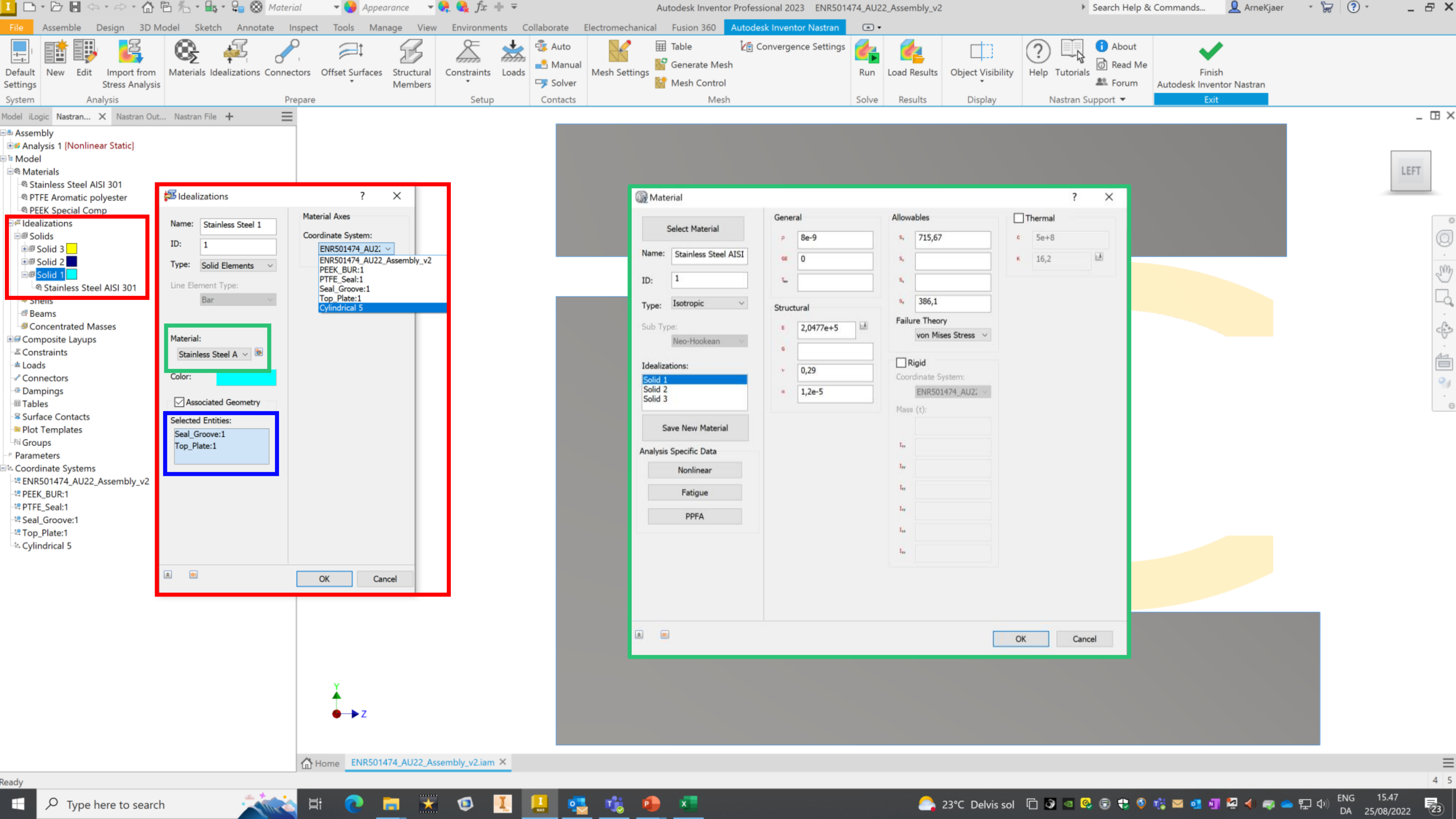
25/08/2022

Material data



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File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
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Assembly
Analysis 1 [Nonlinear Static]
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Stainless Steel AISI 301
PTFE Aromatic polyester
PEEK Special Comp
Idealizations
Solids
Solid 3
Solid 2
Solid 1
Stainless Steel AISI 301
Shells
Beams
Concentrated Masses
Composite Layups
Constraints
Loads
Connectors
Dampings
Tables
Surface Contacts
Plot Templates
Groups
Parameters
Coordinate Systems
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Seal_Groove:1
Top_Plate:1
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Idealizations
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ID: 1
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Line Element Type:
Bar
Material:
Stainless Steel A
Color:
Associated Geometry
Selected Entities:
Seal_Groove:1
Top_Plate:1
Material Axes
Coordinate System:
ENR501474_AU22_Assembly_v2
PEEK_BUR:1
PTFE_Seal:1
Seal_Groove:1
Top_Plate:1
Cylindrical 5
OK
Cancel
Material
Select Material
Name: Stainless Steel AISI
ID: 1
Type: Isotropic
Sub Type: Neo-Hookean
Idealizations:
Solid 1
Solid 2
Solid 3
Save New Material
Analysis Specific Data
Nonlinear
Fatigue
PPFA
General
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Structural
2,0477e+5
0,29
1,2e-5
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Rigid
Coordinate System:
ENR501474_AU2
Mass (t):
Thermal
5e+8
16,2
OK
Cancel
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23°C Delvis sol
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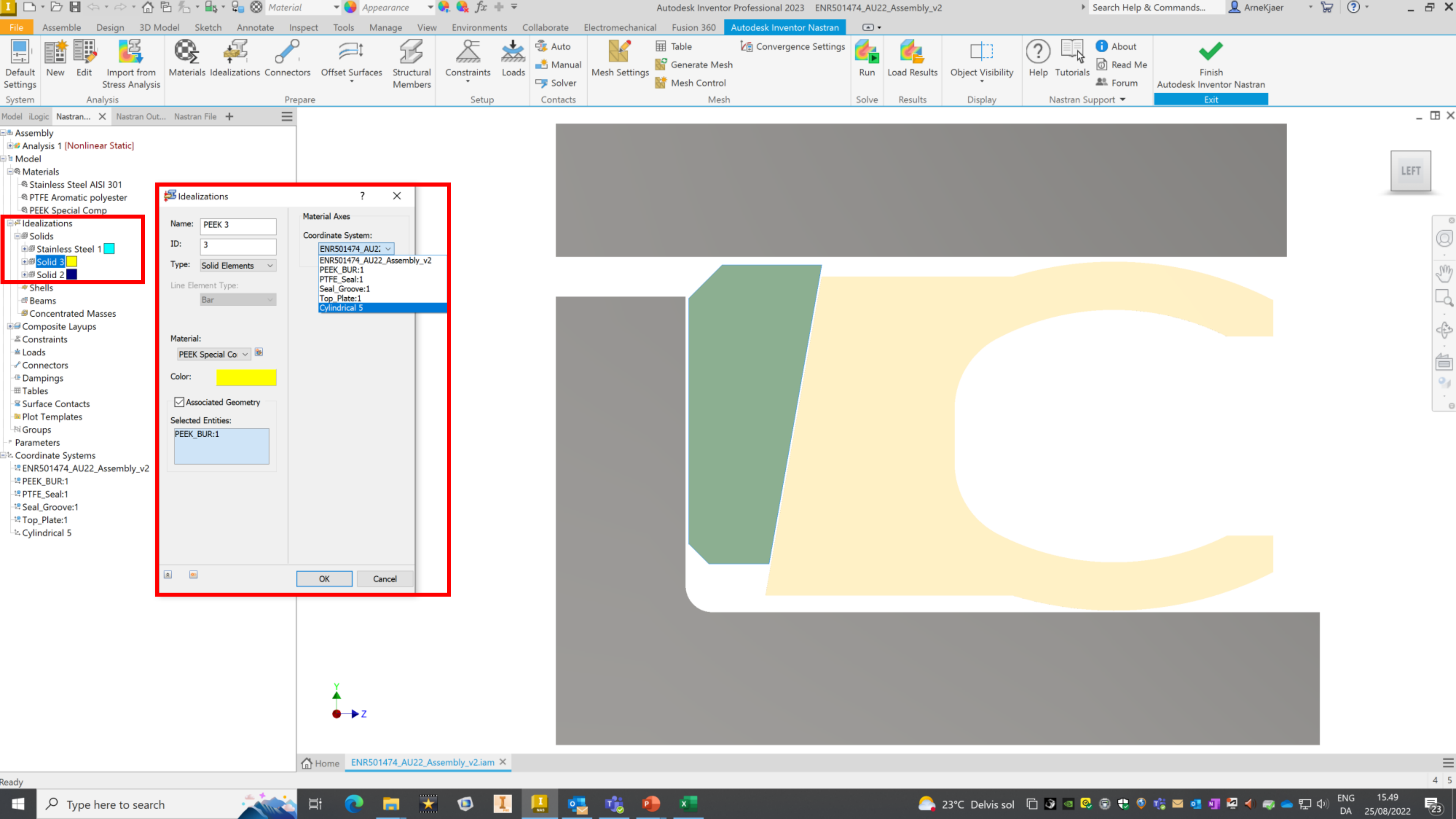
25/08/2022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Assemble
Design
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Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Assembly
Analysis 1 [Nonlinear Static]
Model
Materials
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PTFE Aromatic polyester
PEEK Special Comp
Idealizations
Solids
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Solid 2
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Constraints
Loads
Connectors
Dampings
Tables
Surface Contacts
Plot Templates
Groups
Parameters
Coordinate Systems
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ID: 3
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Line Element Type:
Bar
Material:
PEEK Special Co
Color:
Associated Geometry
Selected Entities:
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Material Axes
Coordinate System:
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ENR501474_AU22_Assembly_v2
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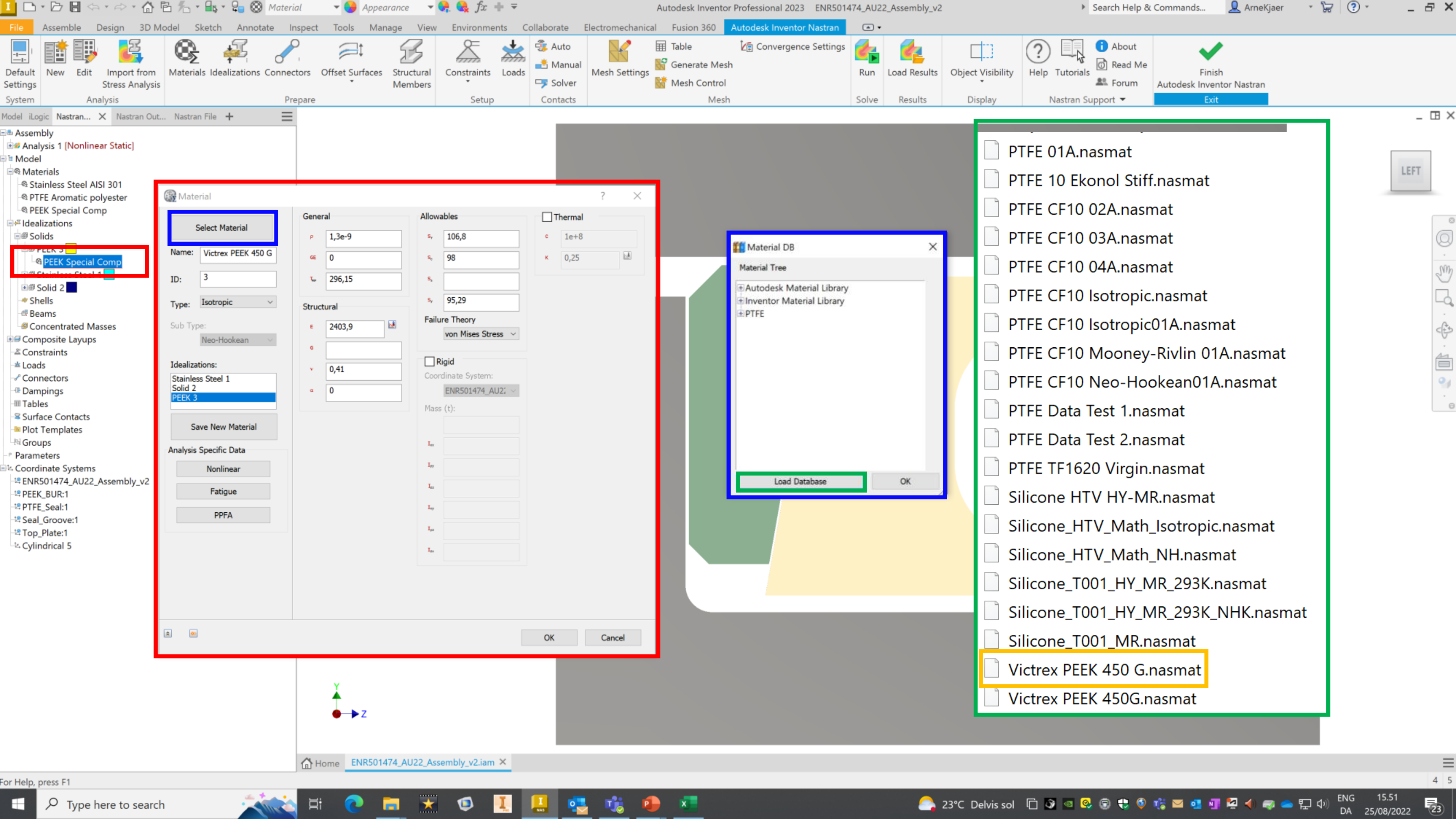
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File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
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New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System Analysis Prepare Setup Contacts Mesh Solve Results Display Nastran Support Exit
Assembly
Analysis 1 [Nonlinear Static]
Model
Materials
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Loads
Connectors
Dampings
Tables
Surface Contacts
Plot Templates
Groups
Parameters
Coordinate Systems
ENR501474_AU22_Assembly_v2
PEEK_BUR:1
PTFE_Seal:1
Seal_Groove:1
Top_Plate:1
Cylindrical 5
Material
Select Material
Name: Victrex PEEK 450 G
ID: 3
Type: Isotropic
Sub Type: Neo-Hookean
Idealizations:
Stainless Steel 1
Solid 2
PEEK 3
Save New Material
Analysis Specific Data
Nonlinear
Fatigue
PPFA
General
1,3e-9
0
296,15
Structural
2403,9
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0
Allowables
106,8
98
95,29
Failure Theory
von Mises Stress
Rigid
Coordinate System:
Mass (t):
Thermal
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OK
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Material DB
Material Tree
Autodesk Material Library
Inventor Material Library
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PTFE 10 Ekonol Stiff.nasmat
PTFE CF10 02A.nasmat
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PTFE CF10 04A.nasmat
PTFE CF10 Isotropic.nasmat
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PTFE CF10 Mooney-Rivlin 01A.nasmat
PTFE CF10 Neo-Hookean01A.nasmat
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PTFE Data Test 2.nasmat
PTFE TF1620 Virgin.nasmat
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Silicone_HTV_Math_Isotropic.nasmat
Silicone_HTV_Math_NH.nasmat
Silicone_T001_HY_MR_293K.nasmat
Silicone_T001_HY_MR_293K_NHK.nasmat
Silicone_T001_MR.nasmat
Victrex PEEK 450 G.nasmat
Victrex PEEK 450G.nasmat
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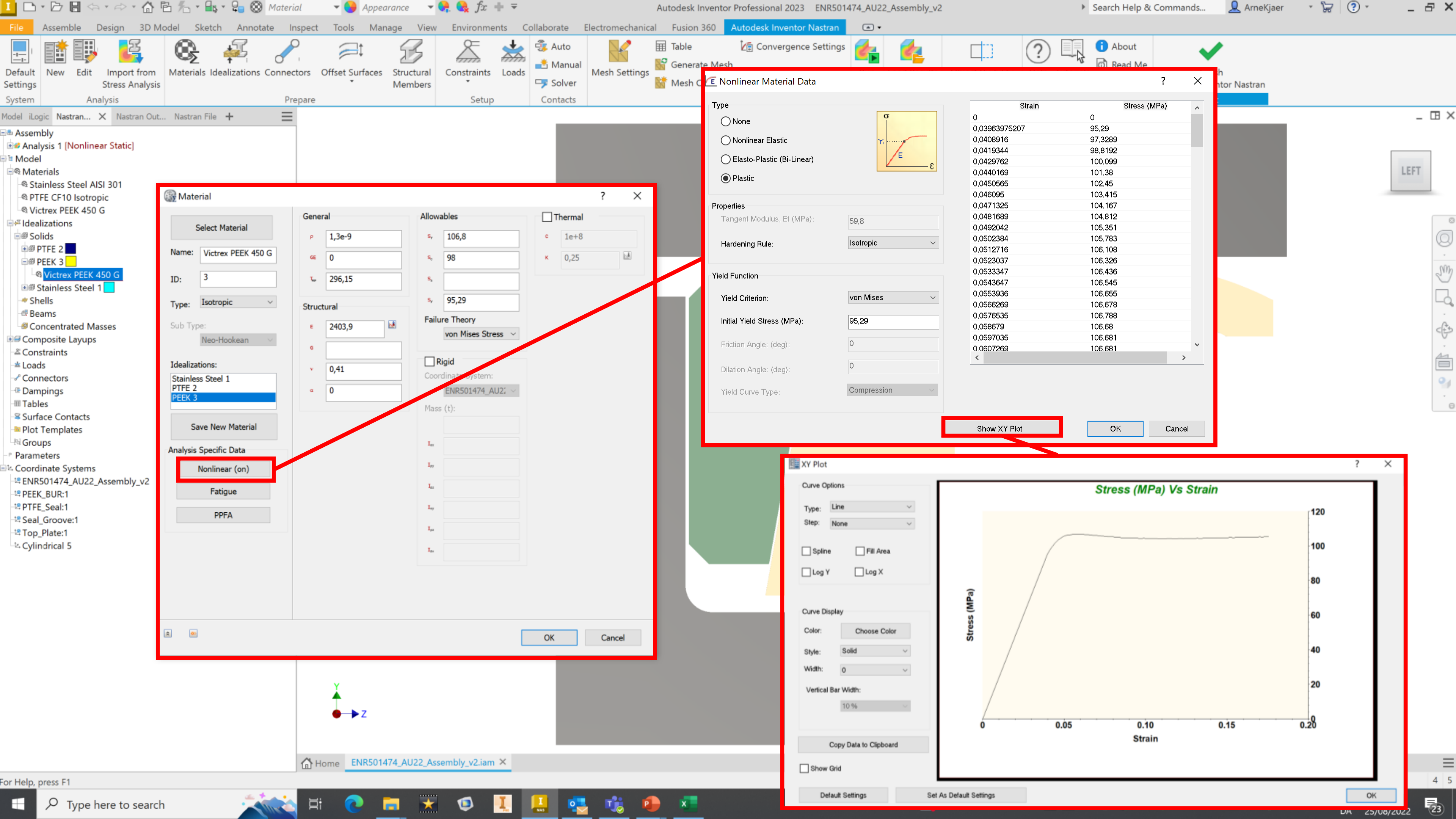
For Help, press F1
Type here to search
23°C Delvis sol
ENG DA 15.51 25/08/2022



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Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Convergence Settings
About
Read Me
System
Analysis
Prepare
Setup
Contacts
Assembly
Analysis 1 [Nonlinear Static]
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Victrex PEEK 450 G
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PTFE 2
PEEK 3
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Surface Contacts
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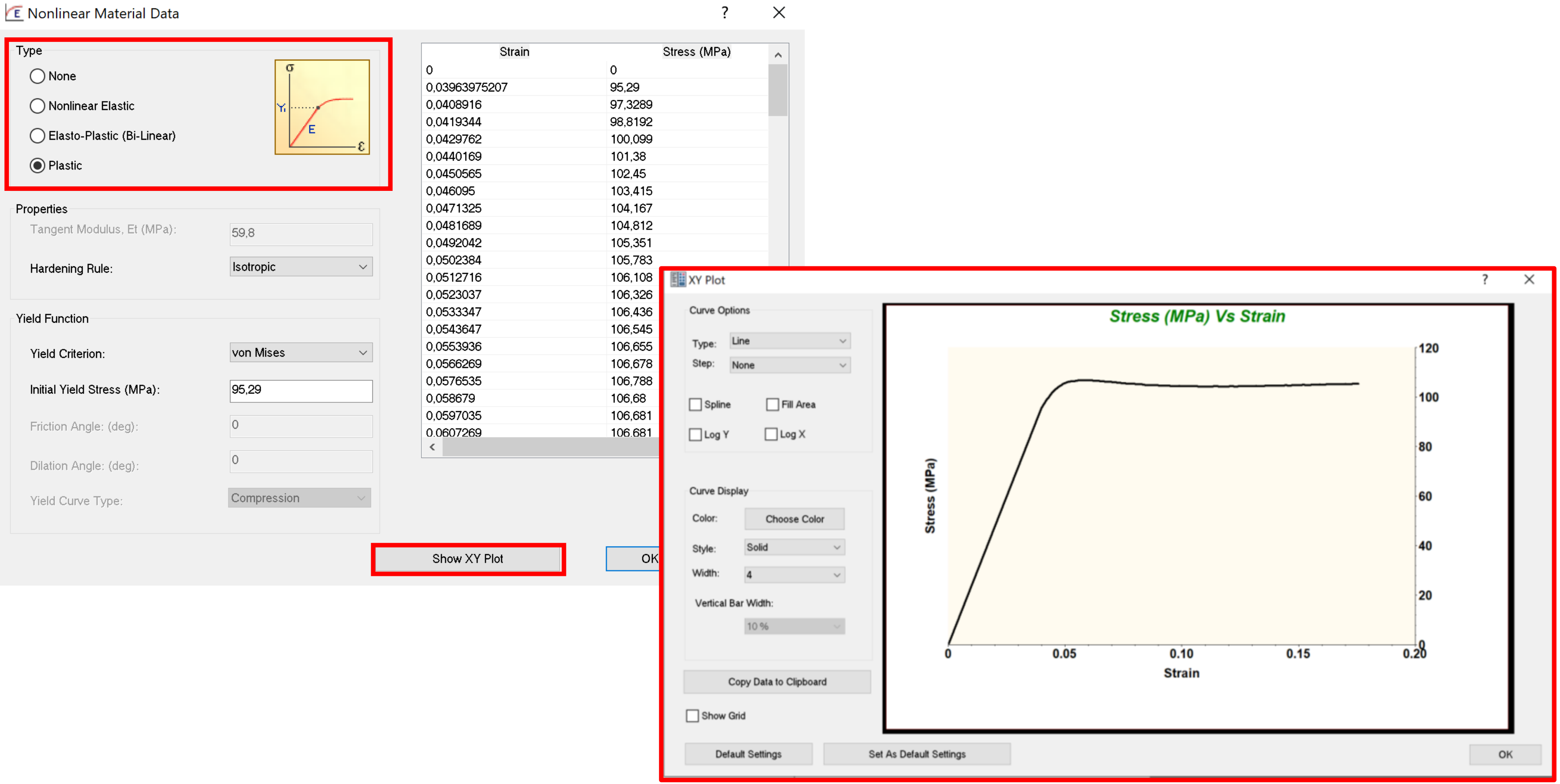
Coordinate Systems
ENR501474_AU22_Assembly_v2
PEEK_BUR:1
PTFE_Seal:1
Seal_Groove:1
Top_Plate:1
Cylindrical 5
Material
Select Material
Name: Victrex PEEK 450 G
ID: 3
Type: Isotropic
Sub Type: Neo-Hookean
Idealizations:
Stainless Steel 1
PTFE 2
PEEK 3
Save New Material
Analysis Specific Data
Nonlinear (on)
Fatigue
PPFA
General
1,3e-9
0
296,15
Structural
2403,9
0,41
0
Allowables
106,8
98
95,29
Failure Theory
von Mises Stress
Rigid
Thermal
1e+8
0,25
OK
Cancel
Nonlinear Material Data
Type
None
Nonlinear Elastic
Elasto-Plastic (Bi-Linear)
Plastic
Properties
Tangent Modulus, Et (MPa): 59,8
Hardening Rule: Isotropic
Yield Function
Yield Criterion: von Mises
Initial Yield Stress (MPa): 95,29
Friction Angle (deg): 0
Dilation Angle (deg): 0
Yield Curve Type: Compression
Strain | Stress (MPa)
0 | 0
0,03963975207 | 95,29
0,0408916 | 97,3289
0,0419344 | 98,8192
0,0429762 | 100,099
0,0440169 | 101,38
0,0450565 | 102,45
0,046095 | 103,415
0,0471325 | 104,167
0,0481689 | 104,812
0,0492042 | 105,351
0,0502384 | 105,783
0,0512716 | 106,108
0,0523037 | 106,326
0,0533347 | 106,436
0,0543647 | 106,545
0,0553936 | 106,655
0,0566269 | 106,678
0,0576535 | 106,788
0,058679 | 106,68
0,0597035 | 106,681
0,0607269 | 106,681
Show XY Plot
OK
Cancel
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
0.05
0.10
0.15
0.20
20
40
60
80
100
120
Home
ENR501474_AU22_Assembly_v2.iam
For Help, press F1
Type here to search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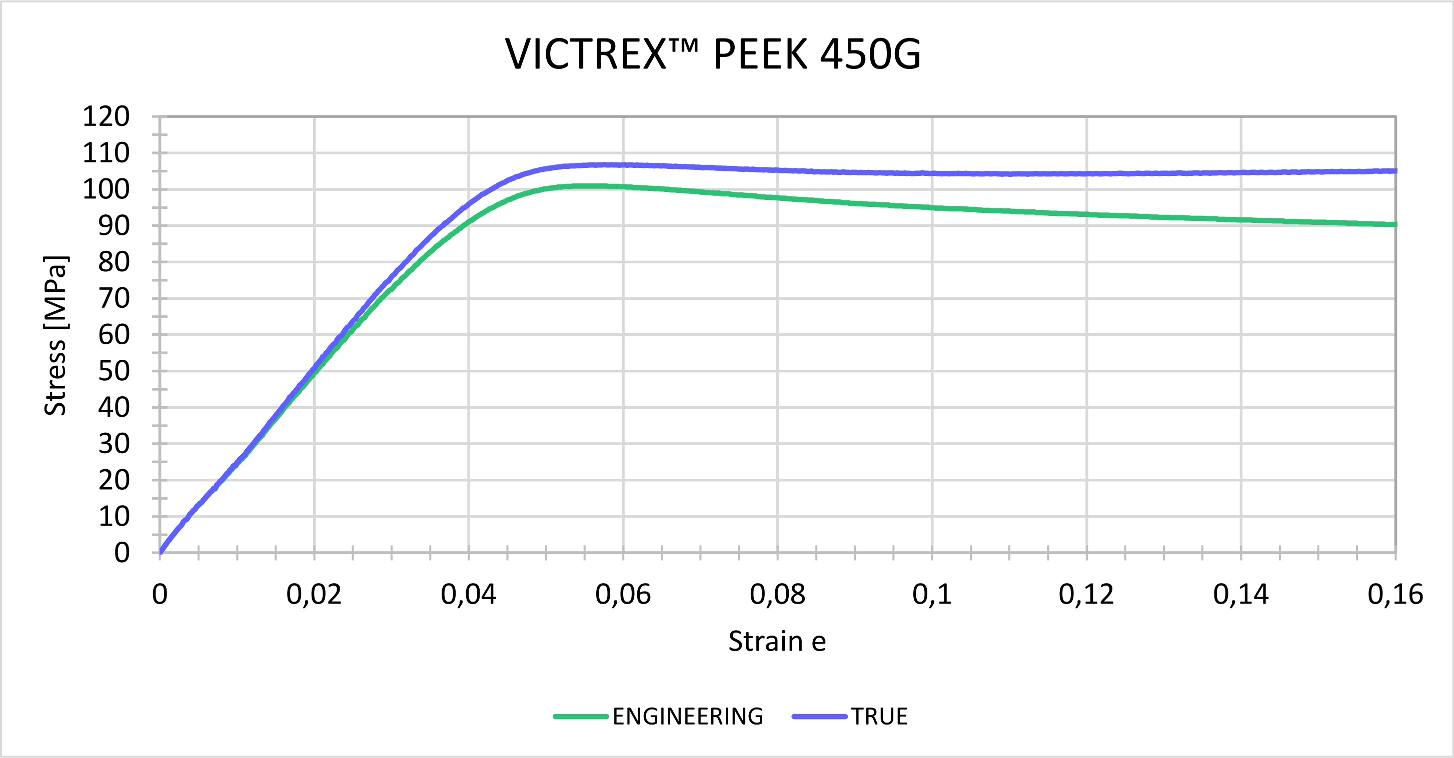
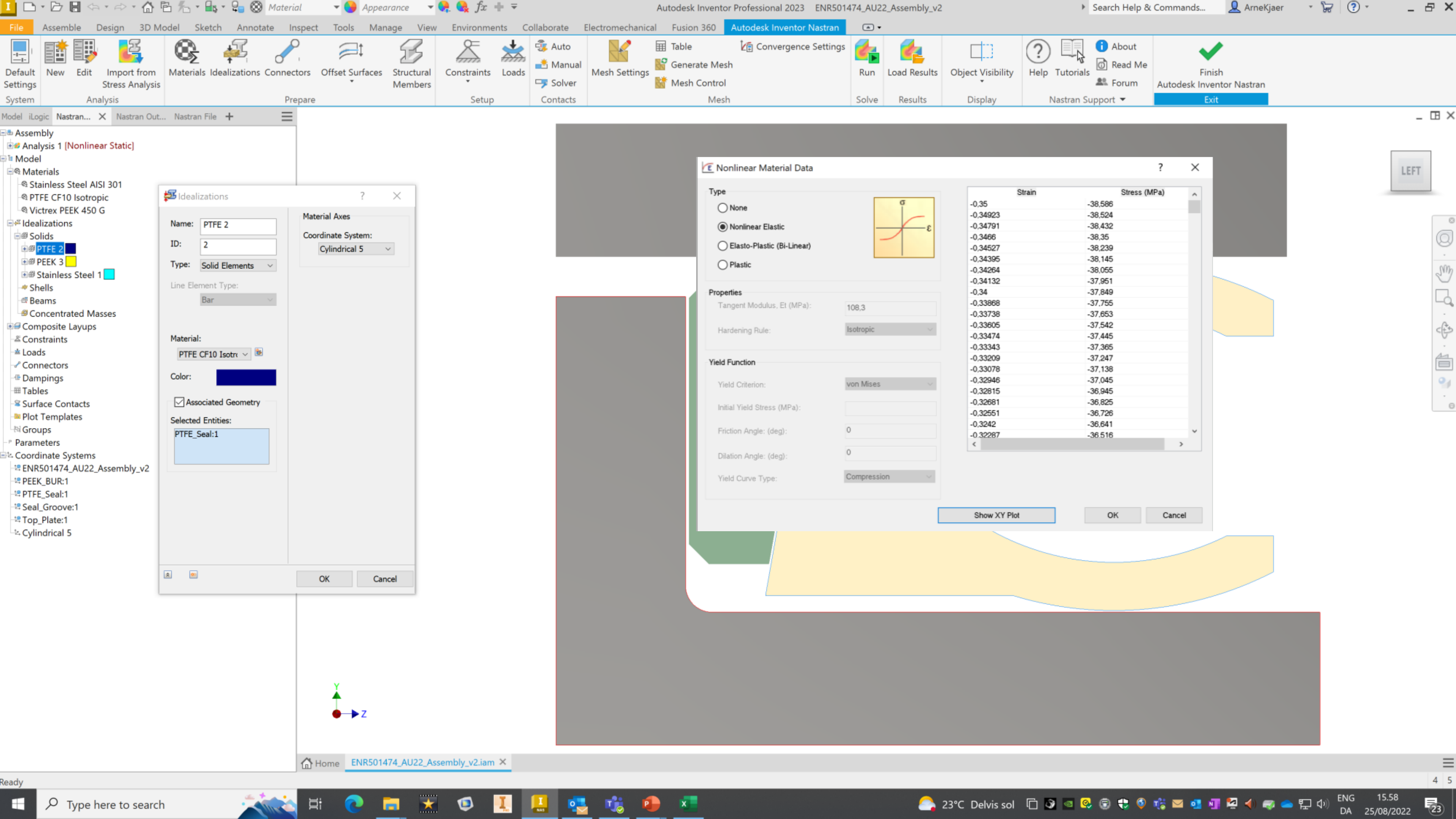
None
Nonlinear Elastic
Elasto-Plastic (Bi-Linear)
Plastic
Properties
Tangent Modulus, Et (MPa): 59,8
Hardening Rule: Isotropic
Yield Function
Yield Criterion: von Mises
Initial Yield Stress (MPa): 95,29
Friction Angle: (deg): 0
Dilation Angle: (deg): 0
Yield Curve Type: Compression
Show XY Plot
OK
Strain | Stress (MPa)
0 | 0
0,03963975207 | 95,29
0,0408916 | 97,3289
0,0419344 | 98,8192
0,0429762 | 100,099
0,0440169 | 101,38
0,0450565 | 102,45
0,046095 | 103,415
0,0471325 | 104,167
0,0481689 | 104,812
0,0492042 | 105,351
0,0502384 | 105,783
0,0512716 | 106,108
0,0523037 | 106,326
0,0533347 | 106,436
0,0543647 | 106,545
0,0553936 | 106,655
0,0566269 | 106,678
0,0576535 | 106,788
0,058679 | 106,68
0,0597035 | 106,681
0,0607269 | 106,681
XY Plot
Curve Options
Type: Line
Step: None
Spline
Fill Area
Log Y
Log X
Curve Display
Color: Choose Color
Style: Solid
Width: 4
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
0.05
0.10
0.15
0.20
20
40
60
80
100
120

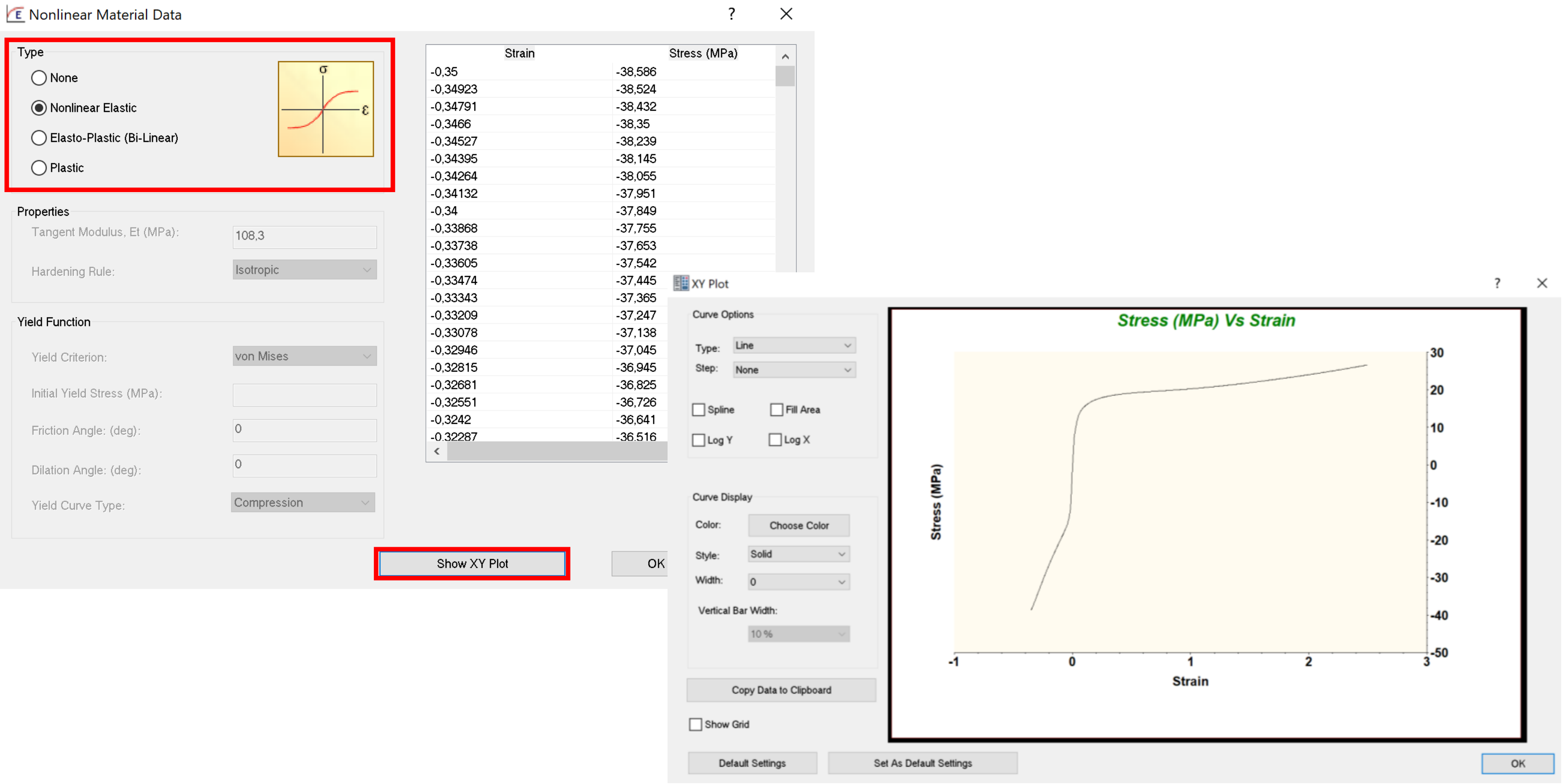
Material data kindly provided by

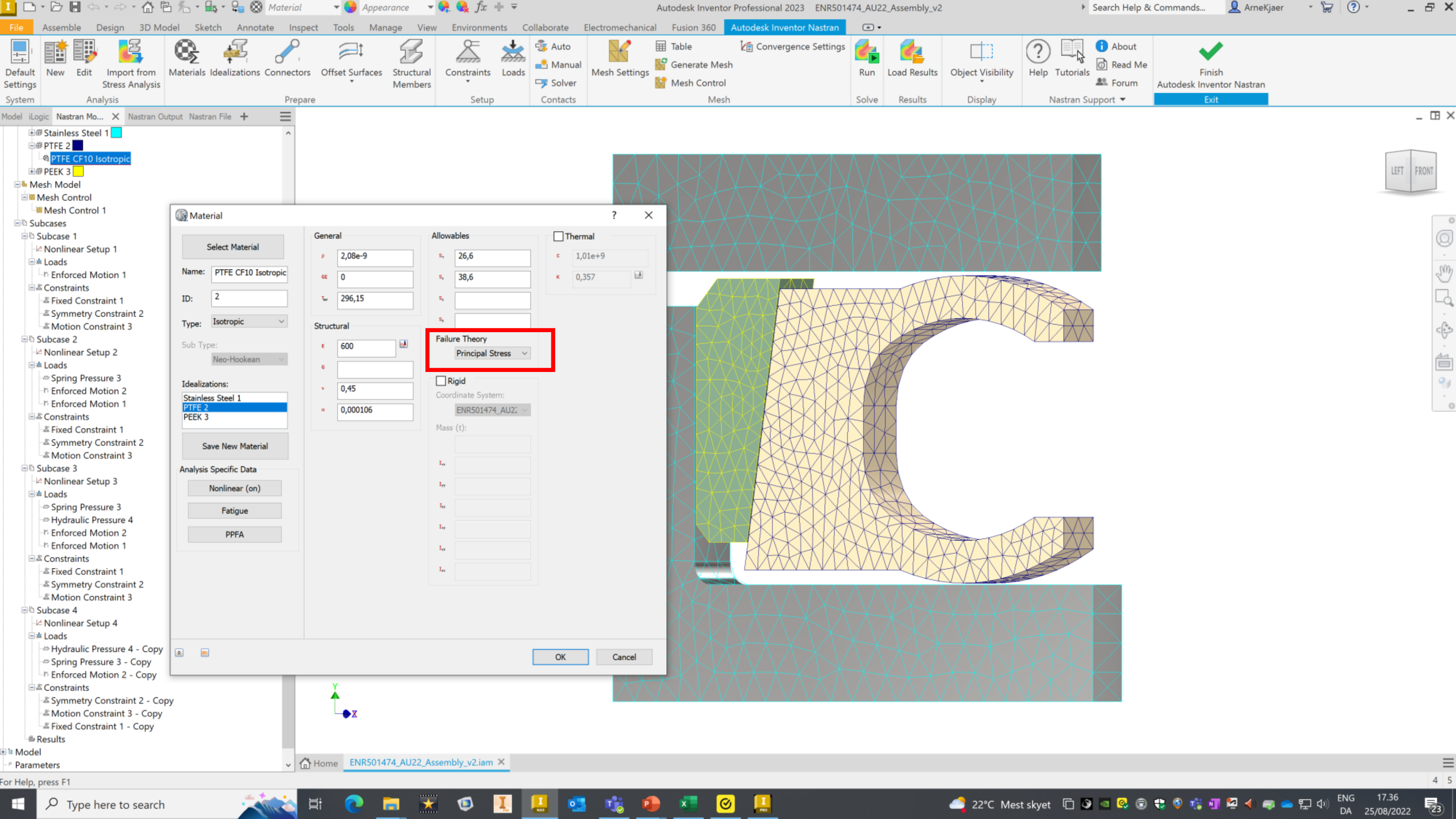
Dr John Grasmeder, Chief Scientist, Victrex plc, Victrex Technology Centre





Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System Analysis Prepare Setup Contacts Mesh Solve Results Display Nastran Support Exit
Assembly
Analysis 1 [Nonlinear Static]
Model
Materials
Stainless Steel AISI 301
PTFE CF10 Isotropic
Victrex PEEK 450 G
Idealizations
Solids
PTFE 2
PEEK 3
Stainless Steel 1
Shells
Beams
Concentrated Masses
Composite Layups
Constraints
Loads
Connectors
Dampings
Tables
Surface Contacts
Plot Templates
Groups
Parameters
Coordinate Systems
ENR501474_AU22_Assembly_v2
PEEK_BUR:1
PTFE_Seal:1
Seal_Groove:1
Top_Plate:1
Cylindrical 5
Idealizations
Name: PTFE 2
ID: 2
Type: Solid Elements
Line Element Type: Bar
Material: PTFE CF10 Isotr
Color:
Associated Geometry
Selected Entities:
PTFE_Seal:1
Material Axes
Coordinate System: Cylindrical 5
OK Cancel
Nonlinear Material Data
Type
None
Nonlinear Elastic
Elasto-Plastic (Bi-Linear)
Plastic
Properties
Tangent Modulus, Et (MPa): 108,3
Hardening Rule: Isotropic
Yield Function
Yield Criterion: von Mises
Initial Yield Stress (MPa):
Friction Angle (deg): 0
Dilation Angle (deg): 0
Yield Curve Type: Compression
Strain Stress (MPa)
-0,35 -38,586
-0,34923 -38,524
-0,34791 -38,432
-0,3466 -38,35
-0,34527 -38,239
-0,34395 -38,145
-0,34264 -38,055
-0,34132 -37,951
-0,34 -37,849
-0,33868 -37,755
-0,33738 -37,653
-0,33605 -37,542
-0,33474 -37,445
-0,33343 -37,365
-0,33209 -37,247
-0,33078 -37,138
-0,32946 -37,045
-0,32815 -36,945
-0,32681 -36,825
-0,32551 -36,726
-0,3242 -36,641
-0,32287 -36,516
Show XY Plot OK Cancel
LEFT
Home ENR501474_AU22_Assembly_v2.iam
Ready
Type here to search
23°C Delvis sol
ENG DA 15.58 25/08/2022


Nonlinear Material Data
Type
None
Nonlinear Elastic
Elasto-Plastic (Bi-Linear)
Plastic
σ
ε
Properties
Tangent Modulus, Et (MPa):
108,3
Hardening Rule:
Isotropic
Yield Function
Yield Criterion:
von Mises
Initial Yield Stress (MPa):
Friction Angle: (deg):
0
Dilation Angle: (deg):
0
Yield Curve Type:
Compression
Show XY Plot
OK
Strain
Stress (MPa)
-0,35 -38,586
-0,34923 -38,524
-0,34791 -38,432
-0,3466 -38,35
-0,34527 -38,239
-0,34395 -38,145
-0,34264 -38,055
-0,34132 -37,951
-0,34 -37,849
-0,33868 -37,755
-0,33738 -37,653
-0,33605 -37,542
-0,33474 -37,445
-0,33343 -37,365
-0,33209 -37,247
-0,33078 -37,138
-0,32946 -37,045
-0,32815 -36,945
-0,32681 -36,825
-0,32551 -36,726
-0,3242 -36,641
-0,32287 -36,516
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
30
20
10
0
-10
-20
-30
-40
-50
-1
0
1
2
3



Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
Stainless Steel 1
PTFE 2
PTFE CF10 Isotropic
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Spring Pressure 3
Enforced Motion 2
Subcase 3
Nonlinear Setup 3
Hydraulic Pressure 4
Subcase 4
Nonlinear Setup 4
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Enforced Motion 2 - Copy
Symmetry Constraint 2 - Copy
Motion Constraint 3 - Copy
Fixed Constraint 1 - Copy
Results
Model
Parameters
Material
Select Material
Name: PTFE CF10 Isotropic
ID: 2
Type: Isotropic
Sub Type: Neo-Hookean
Idealizations:
Stainless Steel 1
PTFE 2
PEEK 3
Save New Material
Analysis Specific Data
Nonlinear (on)
Fatigue
PPFA
General
2,08e-9
0
296,15
Structural
600
0,45
0,000106
Allowables
26,6
38,6
Failure Theory
Principal Stress
Rigid
Coordinate System:
Mass (t):
Thermal
1,01e+9
0,357
OK
Cancel
Home
ENR501474_AU22_Assembly_v2.iam
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Type here to search
22°C Mest skyet
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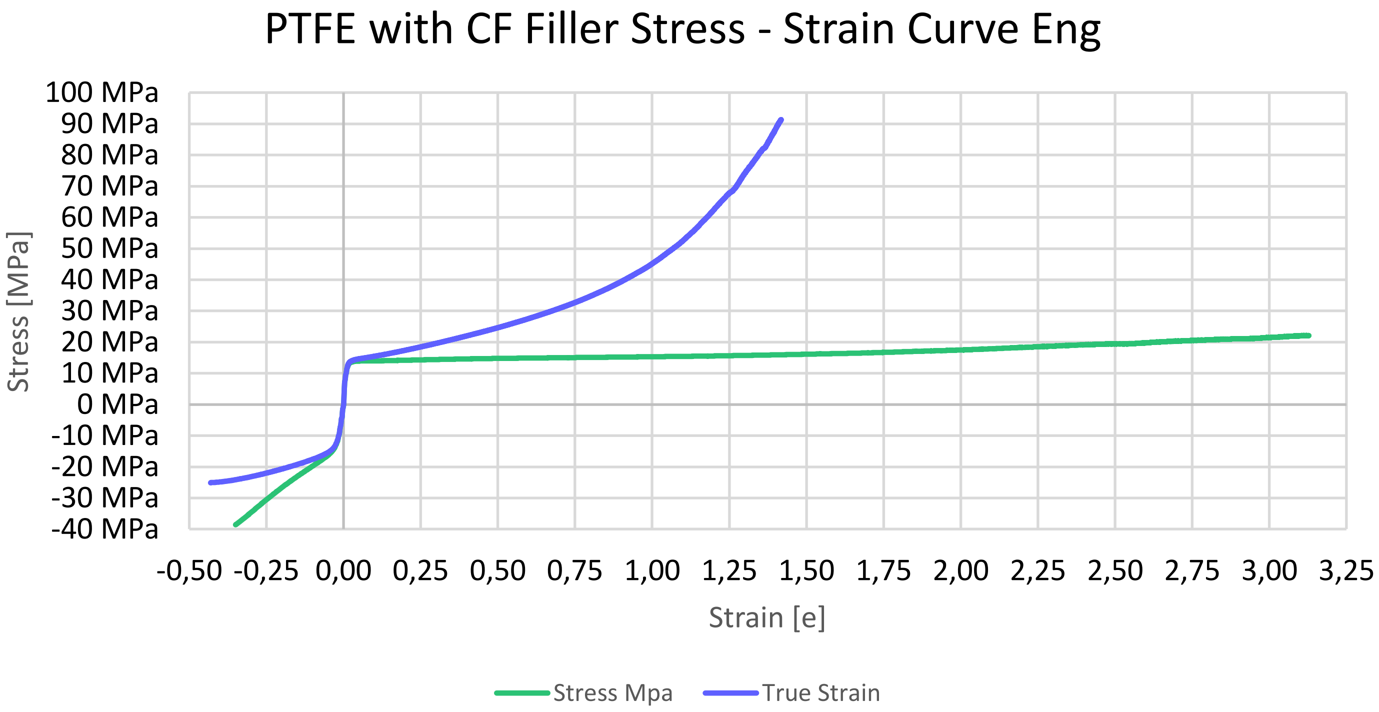
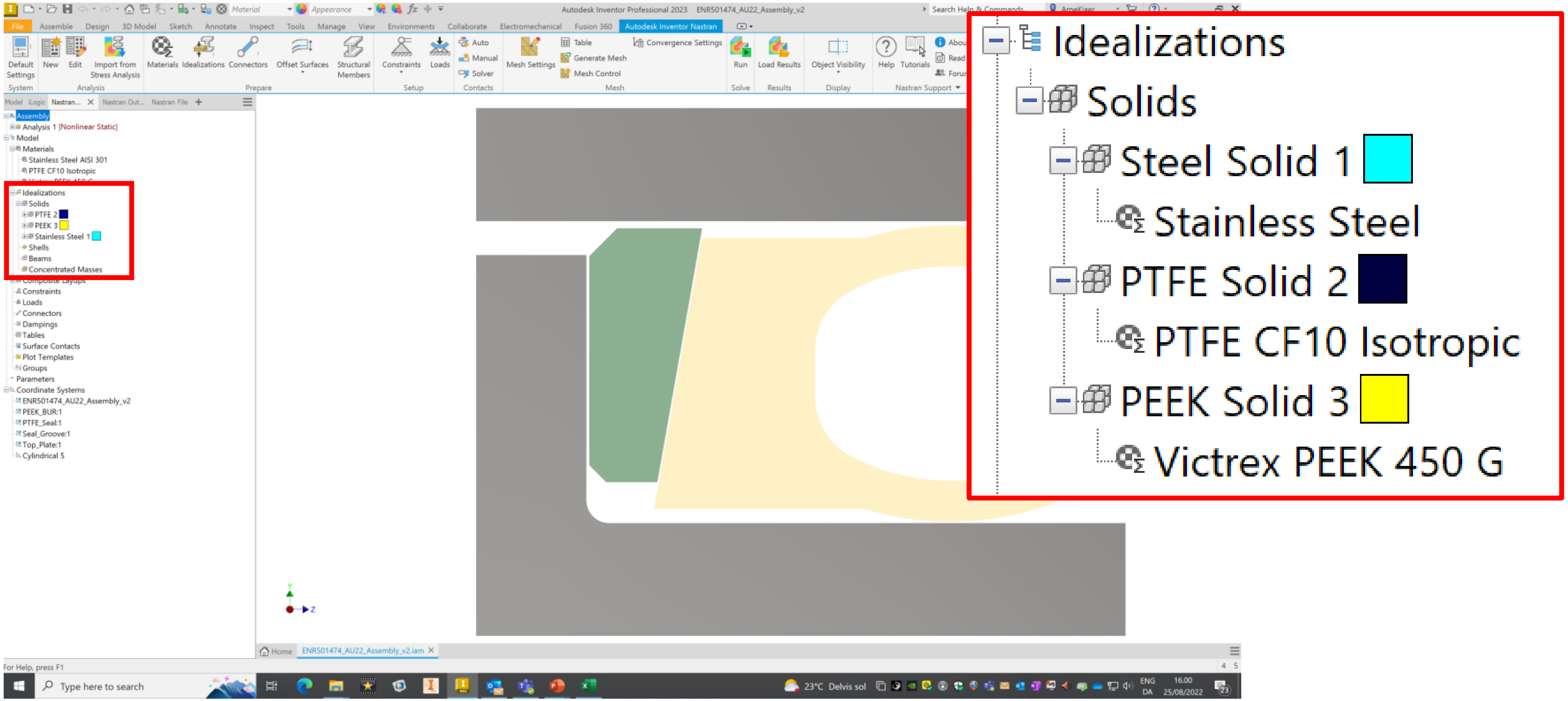
Material data measured and engineered by

PTFE Engineering A/S



Setup of the Nastran 2023



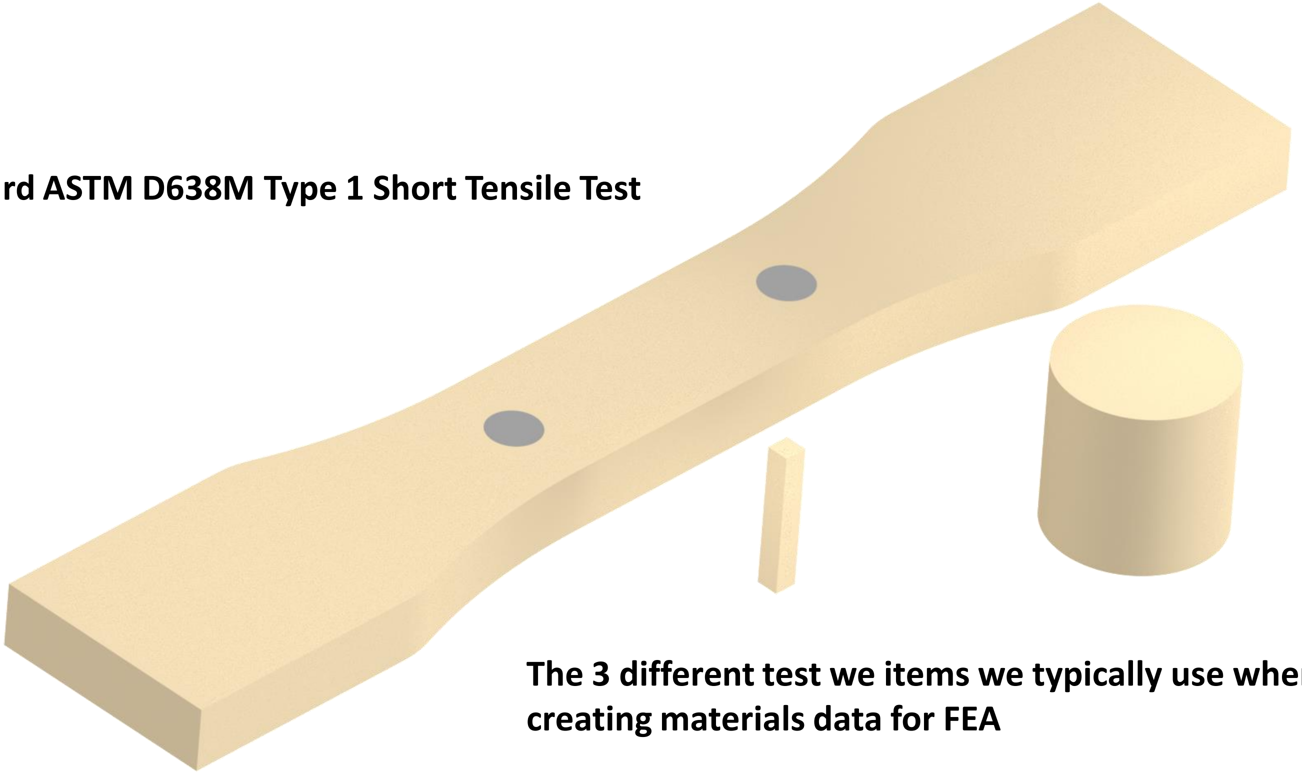
Your Own Material data

PTFE Material Data

- Basically, we now have data to run a simple FEA.
- With a few additional information’s we are actually ready to go with a not too bad first simulation.
- You will also need the following information’s.
  - Mass density (Specific Gravity)
  - Reference Temperature
  - Elastic modulus (Tensions / Compression)
  - Poisson’s Ratio
  - Tensile Limit
  - Compressive Limit
  - Yield Limit (Initial Yield Stress)
  - Tangent Modulus
  - Thermal Expansion Coefficient

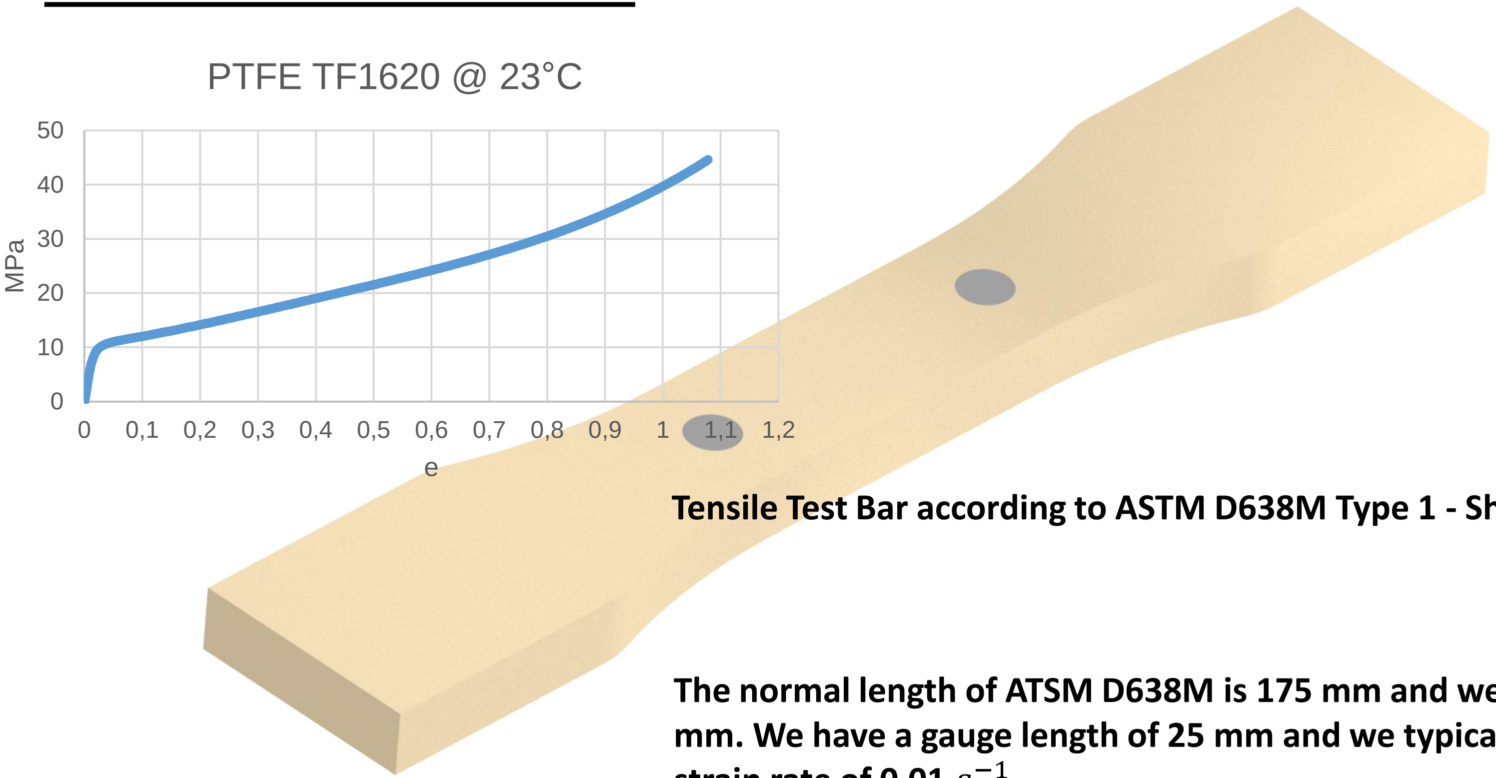
PTFE Material Data

Standard ASTM D638M Type 1 Short Tensile Test



The 3 different test we items we typically use when we start creating materials data for FEA

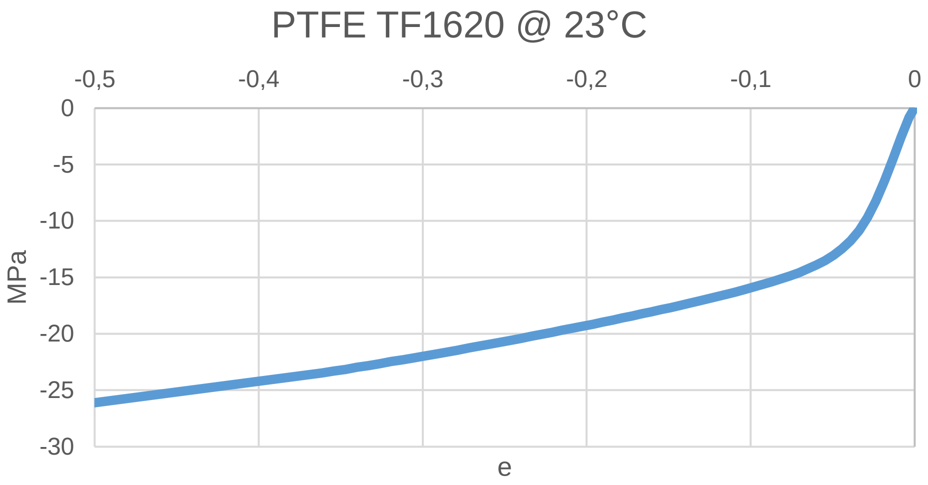
PTFE Material Data

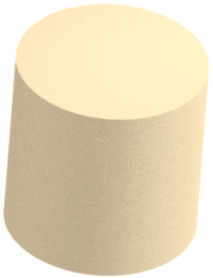


Tensile Test Bar according to ASTM D638M Type 1 - Short

The normal length of ATSM D638M is 175 mm and we use only 100 mm. We have a gauge length of 25 mm and we typically test at a strain rate of 0,01 s^{-1}

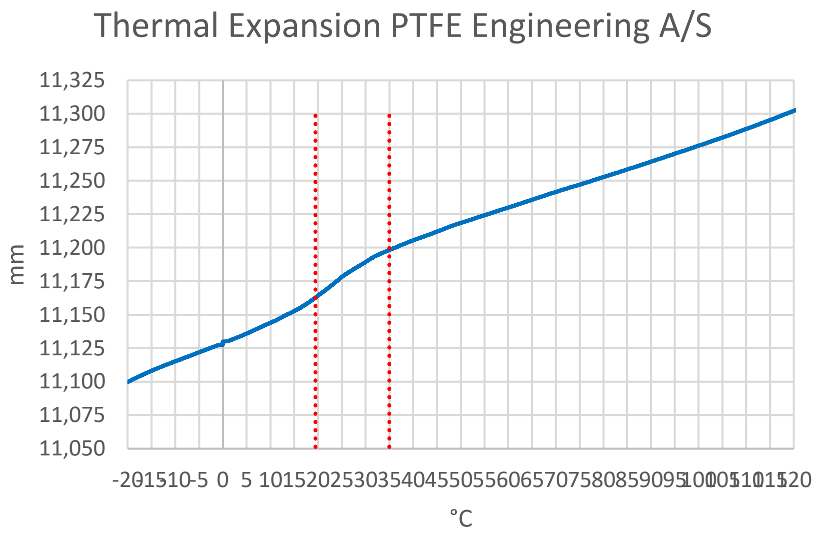
PTFE Material Data





Compression Test Billet
Ø12,7 mm x 12,7 mm

PTFE Material Data



Thermal Expansion Test Bar
1,75 mm x 1,75 mm x 11,0 mm

Engineering stress to True stress

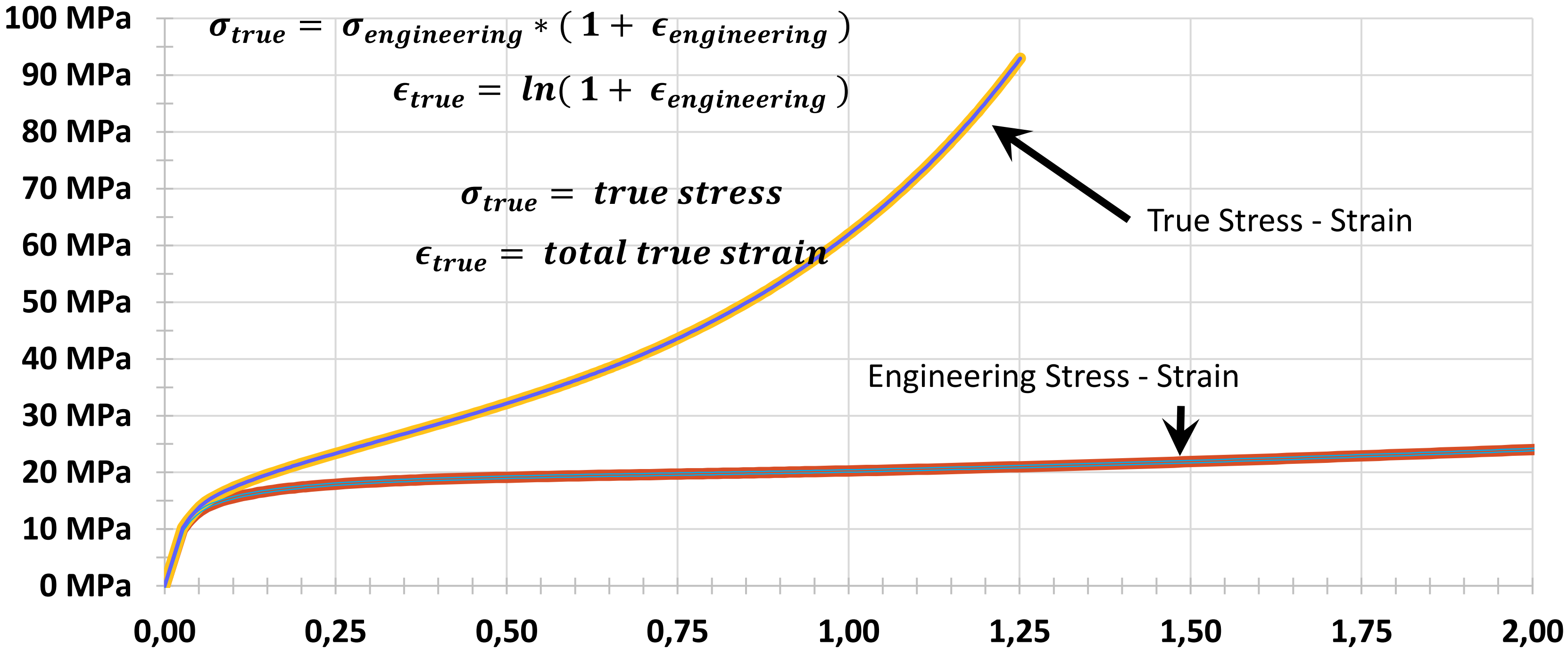
Tensile Test PTFE CF10 03A Eng / True Stress – Strain [MPa]

$$\sigma_{true} = \sigma_{engineering} * (1 + \epsilon_{engineering})$$

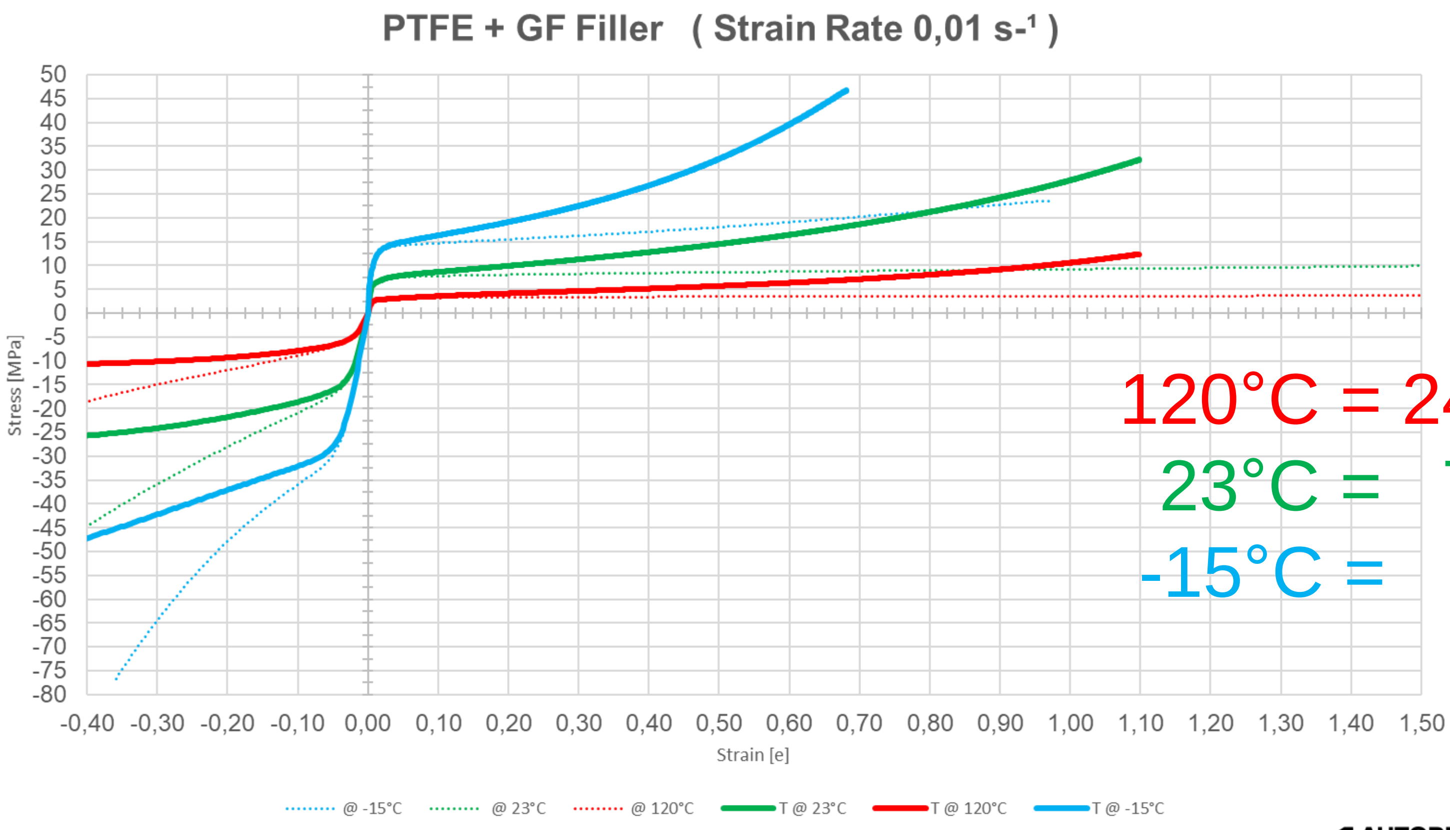
$$\epsilon_{true} = ln(1 + \epsilon_{engineering})$$

$$\sigma_{true} = true\ stress$$

$$\epsilon_{true} = total\ true\ strain$$



PTFE Material Data

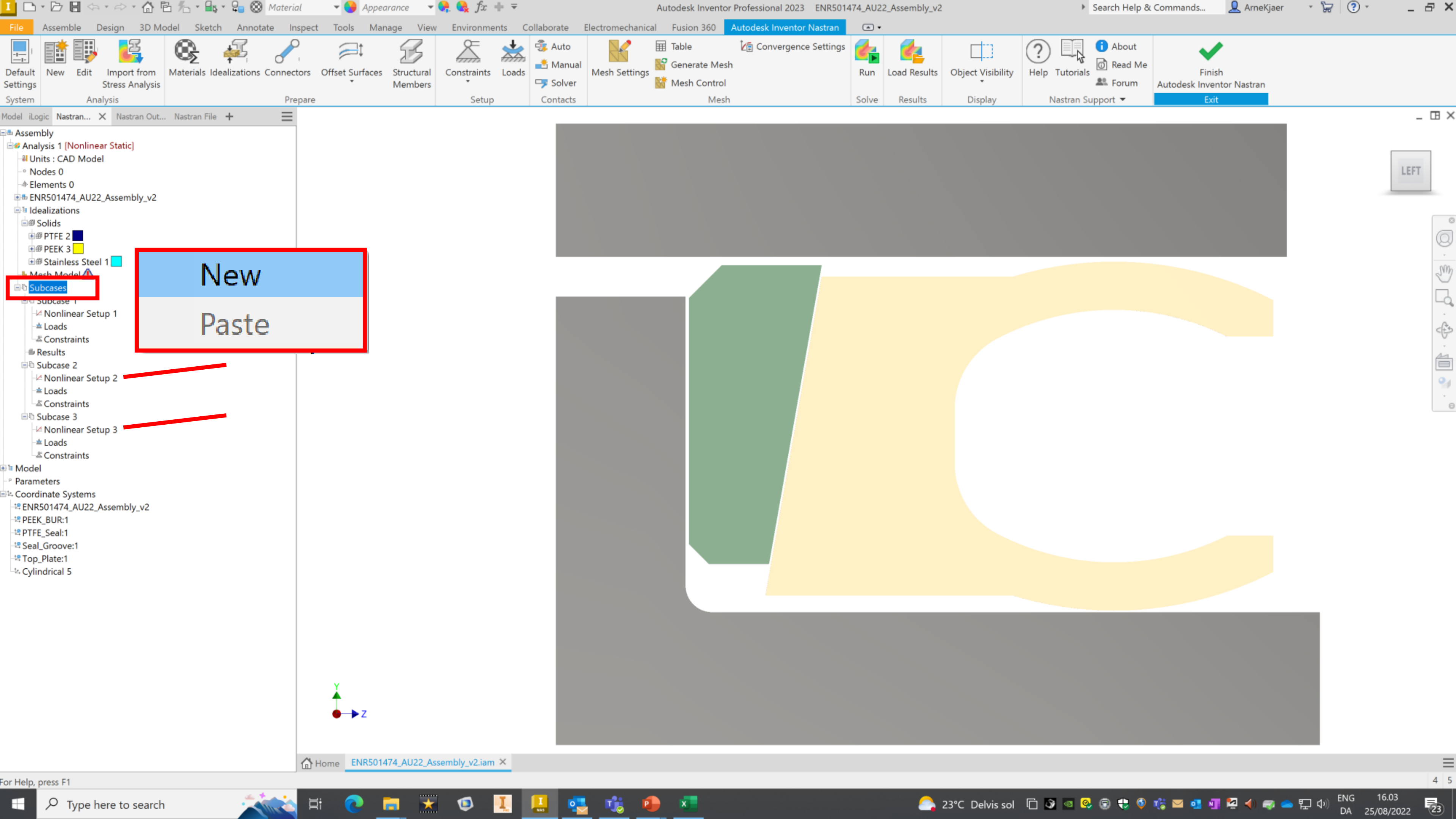


120°C = 248 F

23°C = 73 F

-15°C = 5 F

Subcase Constraints


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
ENR501474_AU22_Assembly_v2
Idealizations
Solids
PTFE 2
PEEK 3
Stainless Steel 1
Subcases
Nonlinear Setup 1
Loads
Constraints
Results
Subcase 2
Nonlinear Setup 2
Loads
Constraints
Subcase 3
Nonlinear Setup 3
Loads
Constraints
Model
Parameters
Coordinate Systems
ENR501474_AU22_Assembly_v2
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PTFE_Seal:1
Seal_Groove:1
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For Help, press F1
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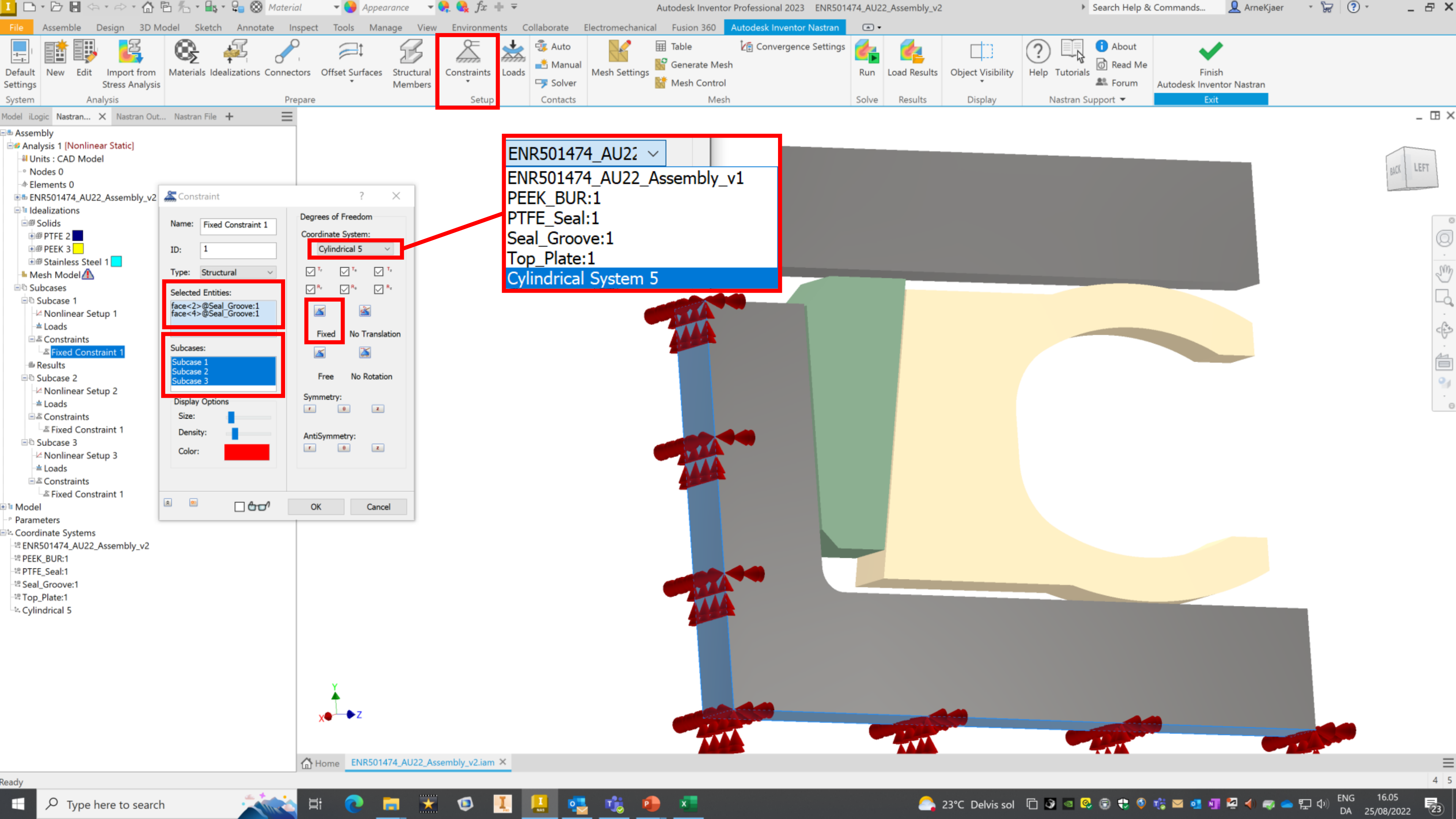

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File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
ENR501474_AU22_Assembly_v2
Idealizations
Solids
PTFE 2
PEEK 3
Stainless Steel 1
Mesh Model
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Constraints
Fixed Constraint 1
Results
Subcase 2
Nonlinear Setup 2
Loads
Constraints
Fixed Constraint 1
Subcase 3
Nonlinear Setup 3
Loads
Constraints
Fixed Constraint 1
Model
Parameters
Coordinate Systems
ENR501474_AU22_Assembly_v2
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PTFE_Seal:1
Seal_Groove:1
Top_Plate:1
Cylindrical 5
Constraint
Name: Fixed Constraint 1
ID: 1
Type: Structural
Selected Entities:
face<2>@Seal_Groove:1
face<4>@Seal_Groove:1
Subcases:
Subcase 1
Subcase 2
Subcase 3
Display Options
Size:
Density:
Color:
Degrees of Freedom
Coordinate System:
Cylindrical 5
Fixed
No Translation
Free
No Rotation
Symmetry:
AntiSymmetry:
OK
Cancel
ENR501474_AU22
ENR501474_AU22_Assembly_v1
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PTFE_Seal:1
Seal_Groove:1
Top_Plate:1
Cylindrical System 5
Home
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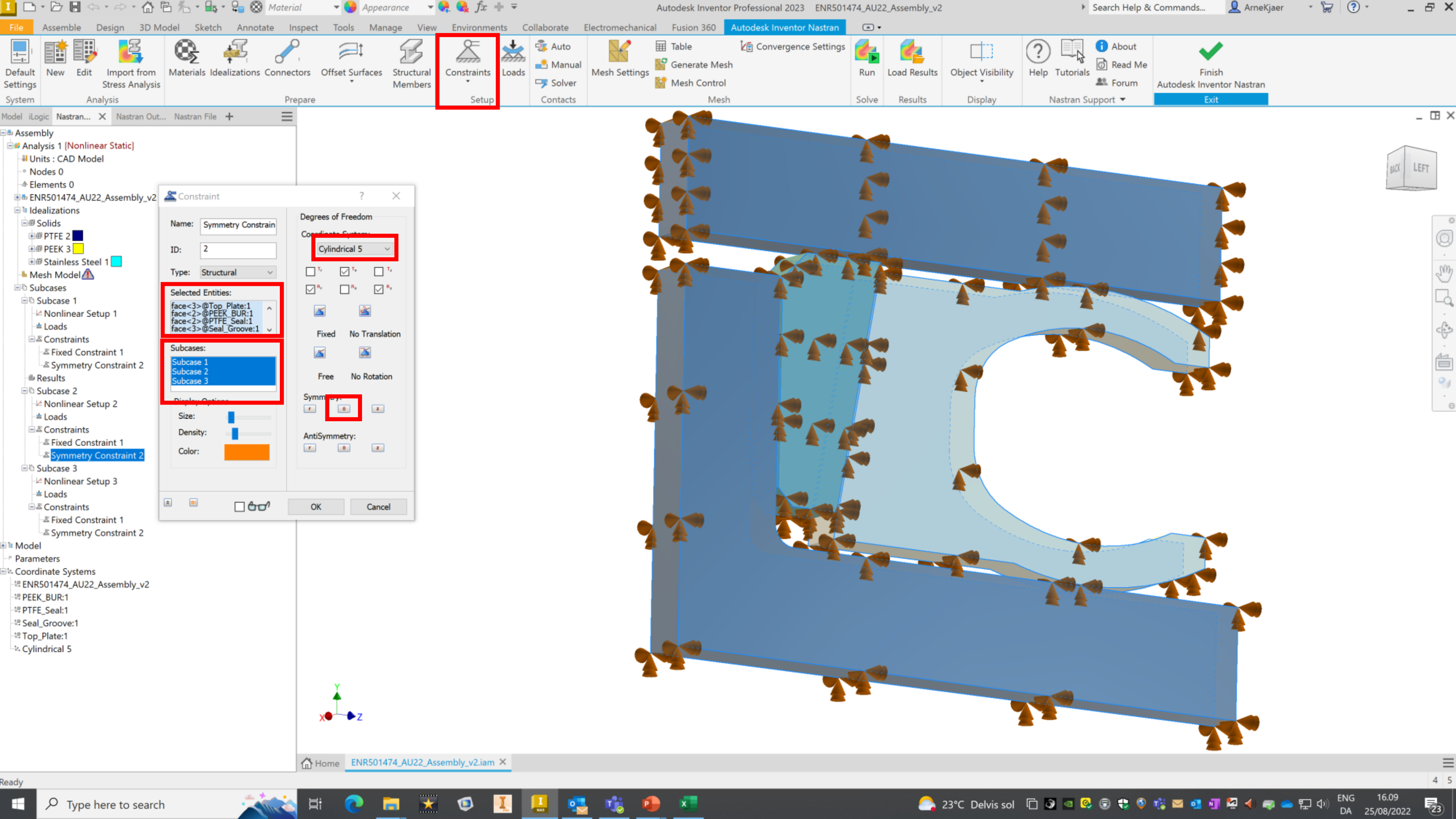
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File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Model
iLogic
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Nastran File
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
ENR501474_AU22_Assembly_v2
Idealizations
Solids
PTFE 2
PEEK 3
Stainless Steel 1
Mesh Model
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Results
Subcase 2
Nonlinear Setup 2
Loads
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Subcase 3
Nonlinear Setup 3
Loads
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Model
Parameters
Coordinate Systems
ENR501474_AU22_Assembly_v2
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PTFE_Seal:1
Seal_Groove:1
Top_Plate:1
Cylindrical 5
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ID: 2
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face<2>@PTFE_Seal:1
face<3>@Seal_Groove:1
Subcases:
Subcase 1
Subcase 2
Subcase 3
Size:
Density:
Color:
Degrees of Freedom
Cylindrical 5
Fixed
No Translation
Free
No Rotation
AntiSymmetry:
OK
Cancel
LEFT
BACK
Home
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Ready
Type here to search
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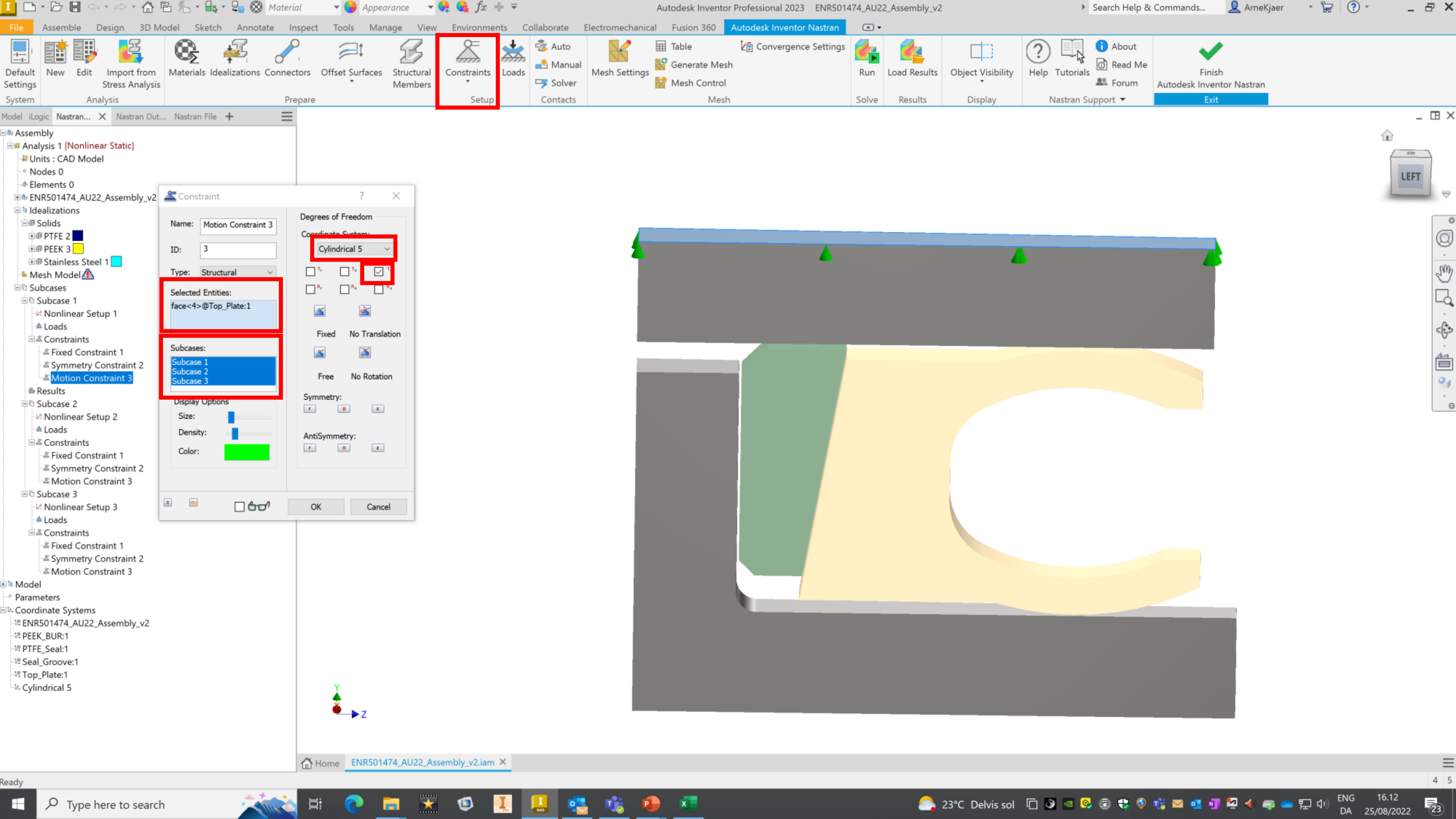
ENG
DA
16.09
25/08/2022


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
ENR501474_AU22_Assembly_v2
Idealizations
Solids
PTFE 2
PEEK 3
Stainless Steel 1
Mesh Model
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Results
Subcase 2
Nonlinear Setup 2
Subcase 3
Nonlinear Setup 3
Model
Parameters
Coordinate Systems
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Seal_Groove:1
Top_Plate:1
Cylindrical 5
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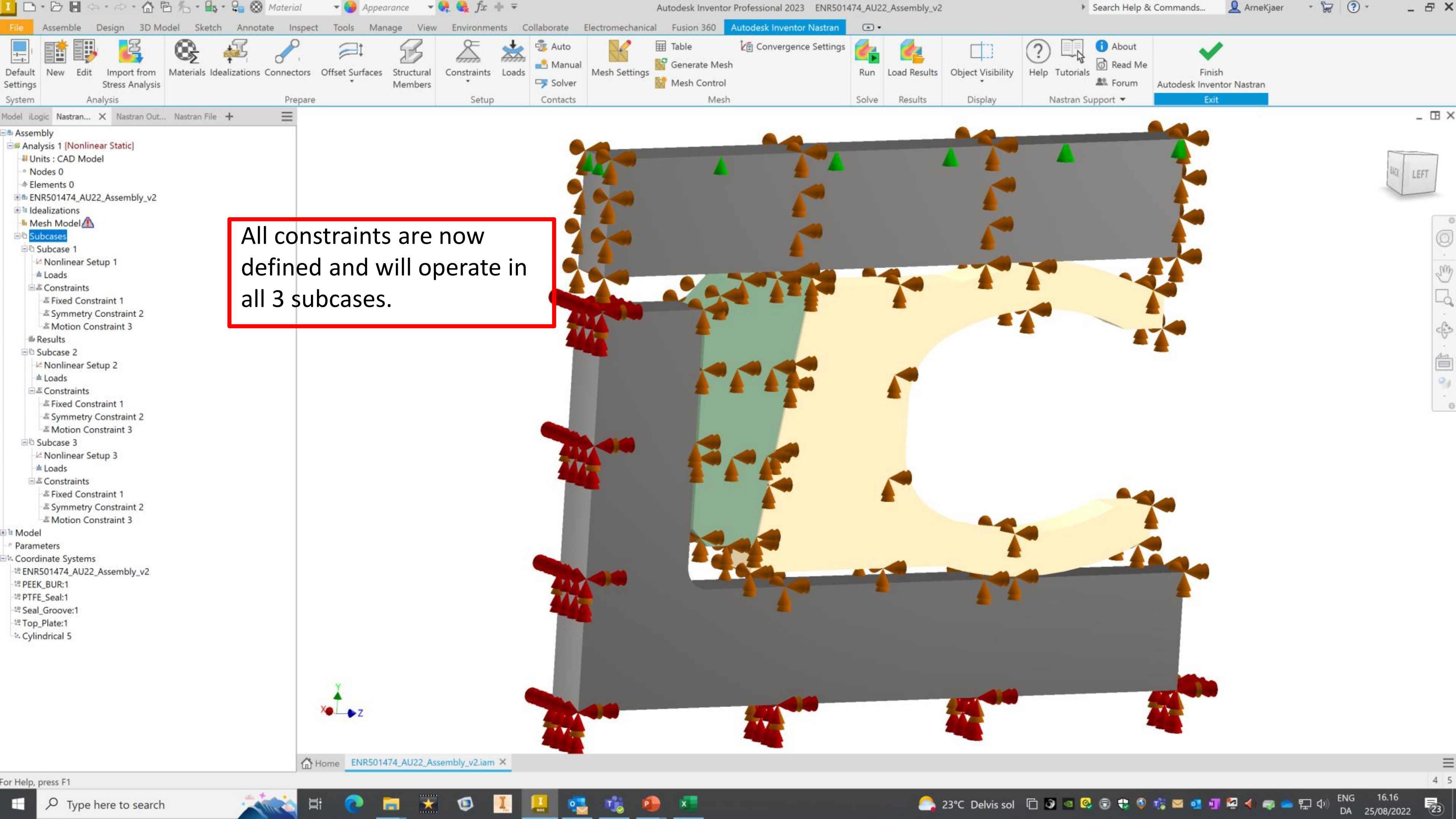
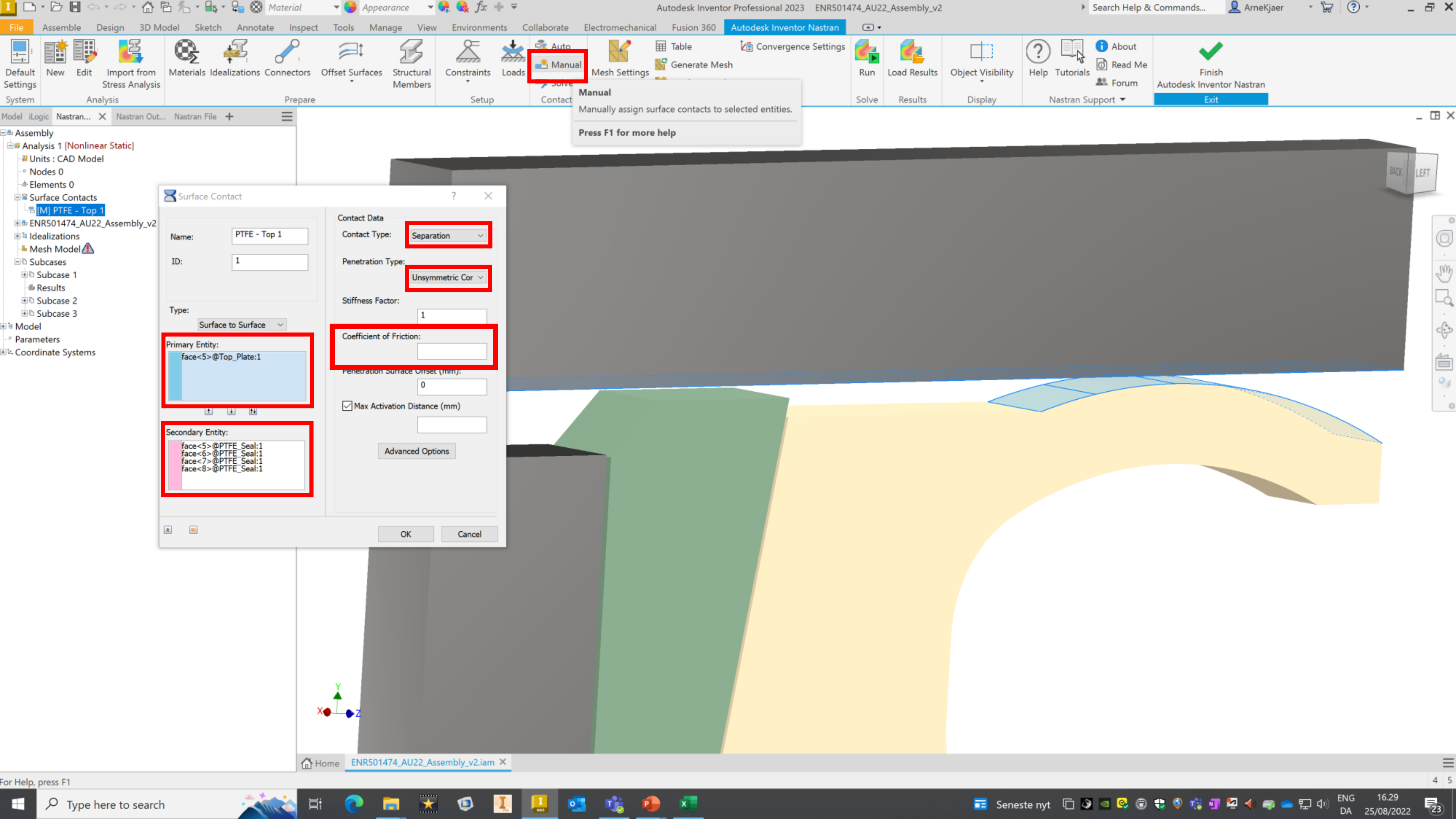
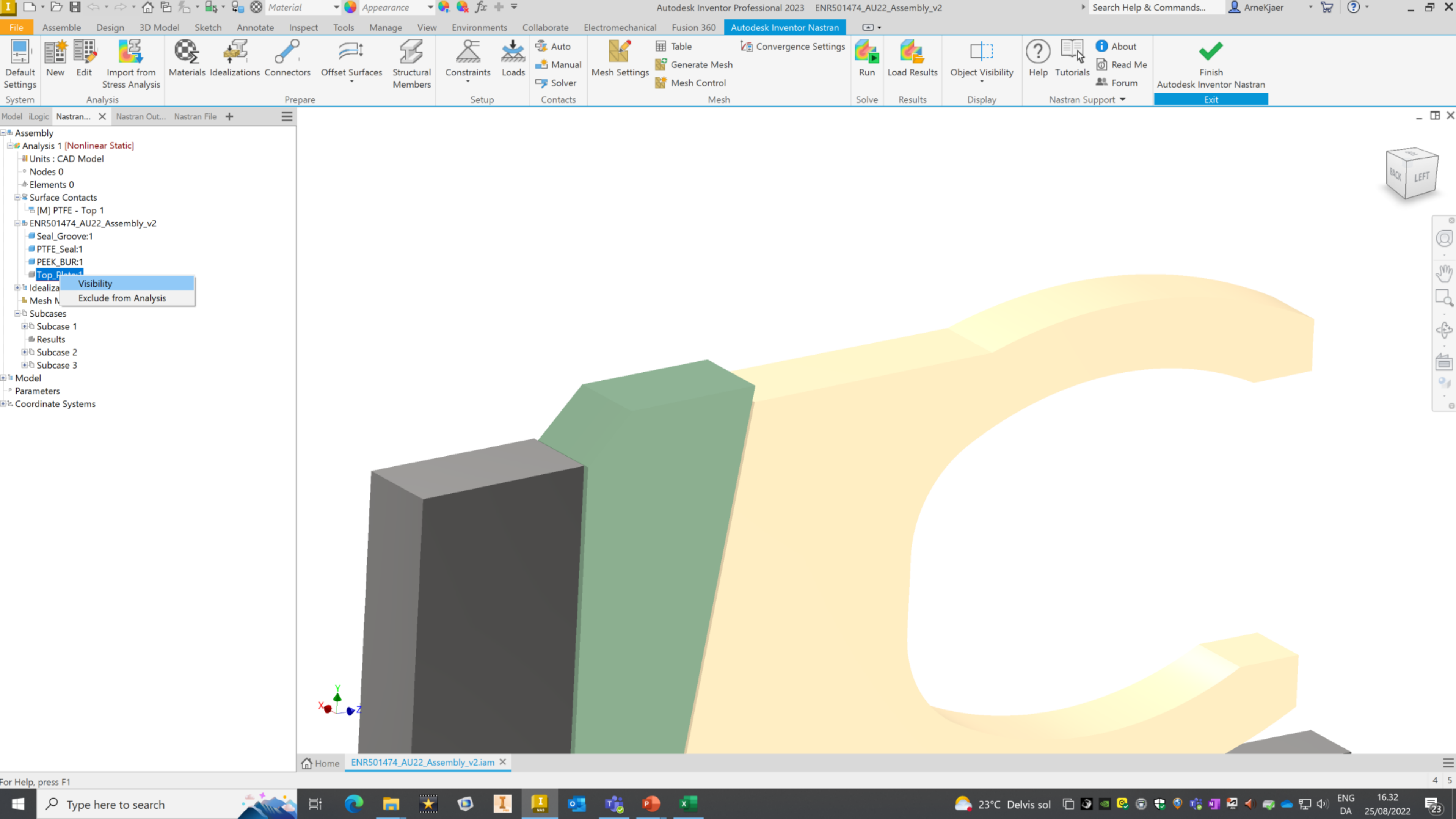
Subcase 1
Subcase 2
Subcase 3
Display Options
Size:
Density:
Color:
Degrees of Freedom
Coordinate System:
Cylindrical 5
Fixed
No Translation
Free
No Rotation
Symmetry:
AntiSymmetry:
OK
Cancel
LEFT
Home
ENR501474_AU22_Assembly_v2.iam
Ready
Type here to search
23°C Delvis sol
ENG
DA
16.12
25/08/2022

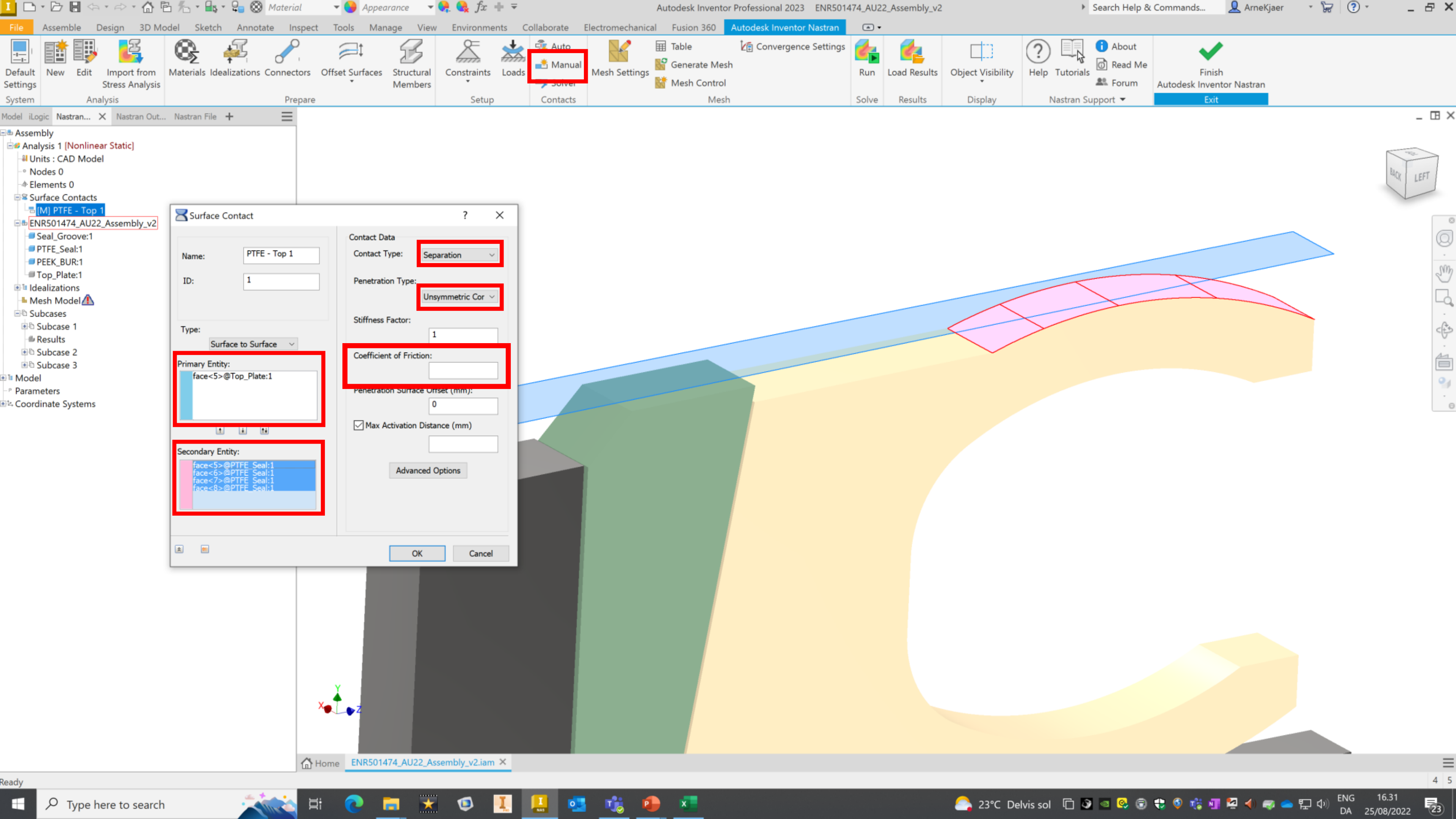
All constraints are now defined and will operate in all 3 subcases.

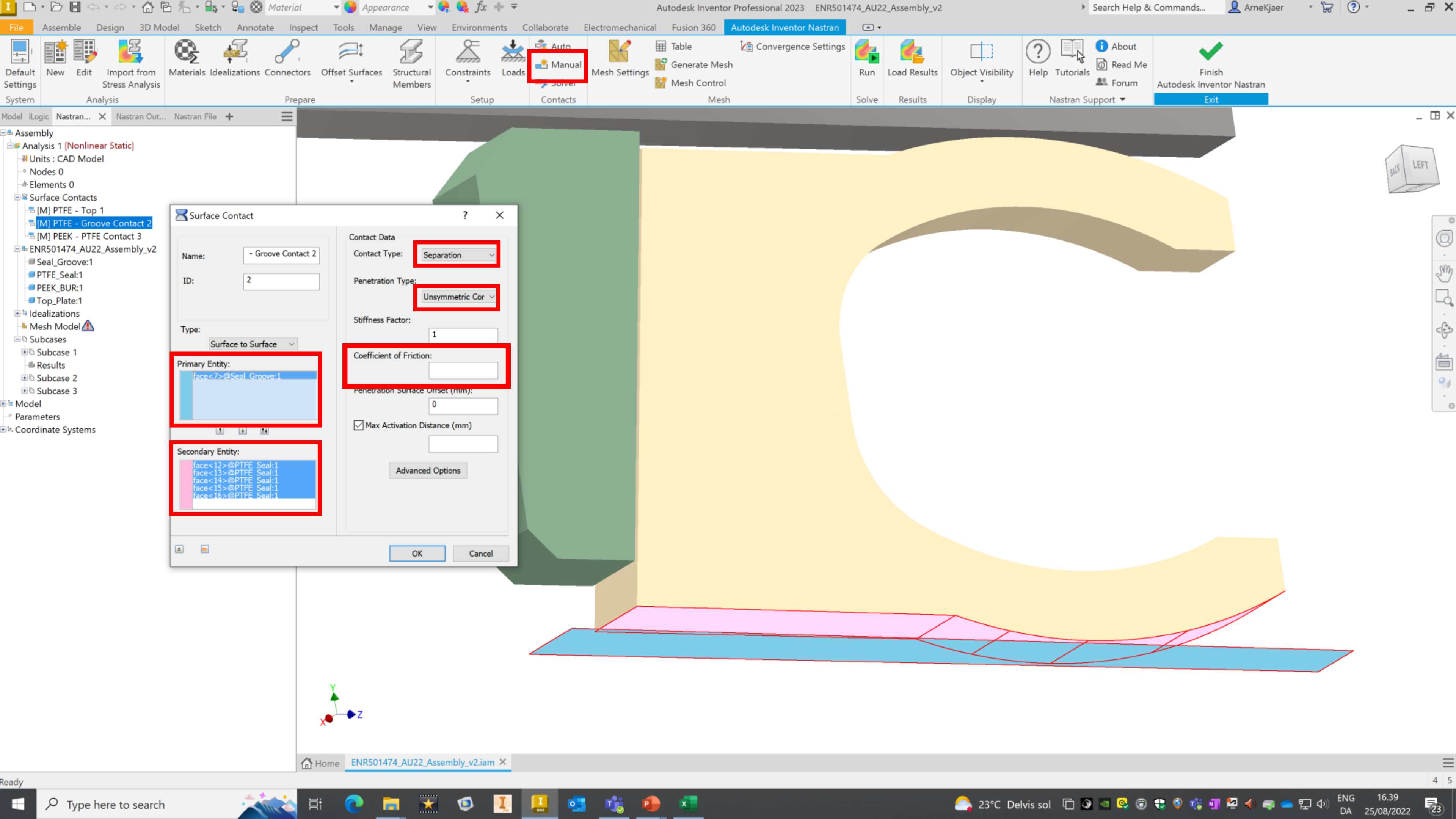


Contacts


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Mesh Settings
Table
Generate Mesh
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System Analysis Prepare Setup Contact Solve Results Display Nastran Support Exit
Manual
Manually assign surface contacts to selected entities.
Press F1 for more help
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
Surface Contacts
[M] PTFE - Top 1
ENR501474_AU22_Assembly_v2
Idealizations
Mesh Model
Subcases
Subcase 1
Results
Subcase 2
Subcase 3
Model
Parameters
Coordinate Systems
Surface Contact
Name: PTFE - Top 1
ID: 1
Type: Surface to Surface
Primary Entity:
face<5>@Top_Plate:1
Secondary Entity:
face<5>@PTFE_Seal:1
face<6>@PTFE_Seal:1
face<7>@PTFE_Seal:1
face<8>@PTFE_Seal:1
Contact Data
Contact Type: Separation
Penetration Type: Unsymmetric Cor
Stiffness Factor: 1
Coefficient of Friction:
Penetration Surface Offset (mm): 0
Max Activation Distance (mm)
Advanced Options
OK
Cancel
ENR501474_AU22_Assembly_v2.iam
For Help, press F1


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
Surface Contacts
[M] PTFE - Top 1
ENR501474_AU22_Assembly_v2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Visibility
Exclude from Analysis
Subcases
Subcase 1
Results
Subcase 2
Subcase 3
Model
Parameters
Coordinate Systems
Home
ENR501474_AU22_Assembly_v2.iam
For Help, press F1
Type here to search
23°C Delvis sol
16.32
25/08/2022


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Autodesk Inventor Nastran
Manual
Surface Contact
Name: PTFE - Top 1
ID: 1
Type: Surface to Surface
Primary Entity:
face<5>@Top_Plate:1
Secondary Entity:
face<5>@PTFE_Seal:1
face<6>@PTFE_Seal:1
face<7>@PTFE_Seal:1
face<8>@PTFE_Seal:1
Contact Data
Contact Type: Separation
Penetration Type: Unsymmetric Cor
Stiffness Factor: 1
Coefficient of Friction:
Penetration Surface Offset (mm): 0
Max Activation Distance (mm)
Advanced Options
OK
Cancel
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
Surface Contacts
[M] PTFE - Top 1
ENR501474_AU22_Assembly_v2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Subcases
Subcase 1
Results
Subcase 2
Subcase 3
Model
Parameters
Coordinate Systems
Ready



Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
Surface Contacts
[M] PTFE - Top 1
[M] PTFE - Groove Contact 2
[M] PEEK - PTFE Contact 3
ENR501474_AU22_Assembly_v2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Subcases
Subcase 1
Results
Subcase 2
Subcase 3
Model
Parameters
Coordinate Systems
Surface Contact
Name: - Groove Contact 2
ID: 2
Type: Surface to Surface
Primary Entity:
face<7>@Seal_Groove:1
Secondary Entity:
face<12>@PTFE_Seal:1
face<13>@PTFE_Seal:1
face<14>@PTFE_Seal:1
face<15>@PTFE_Seal:1
face<16>@PTFE_Seal:1
Contact Data
Contact Type: Separation
Penetration Type: Unsymmetric Cor
Stiffness Factor: 1
Coefficient of Friction:
Penetration Surface Offset (mm): 0
Max Activation Distance (mm)
Advanced Options
OK
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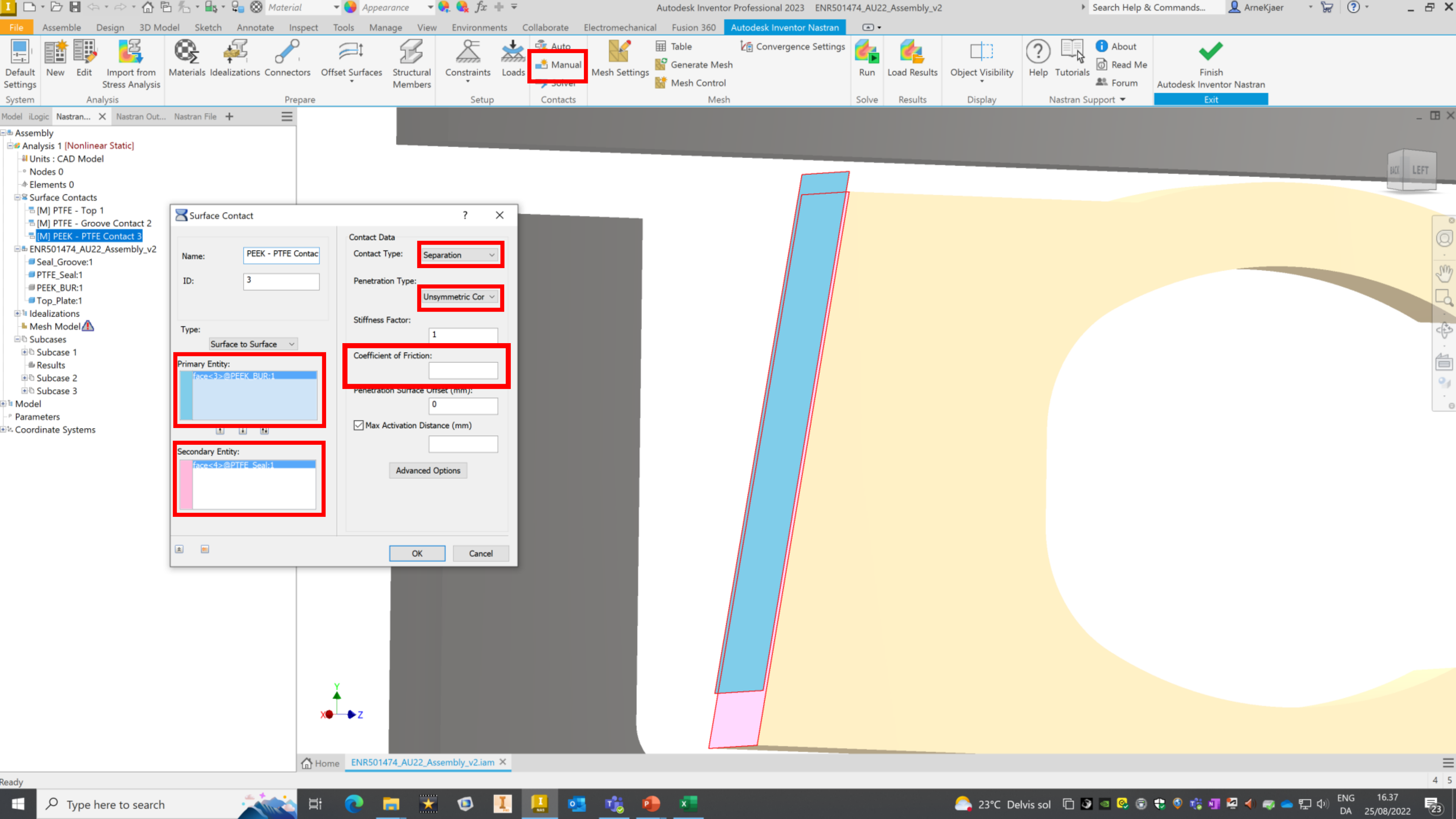
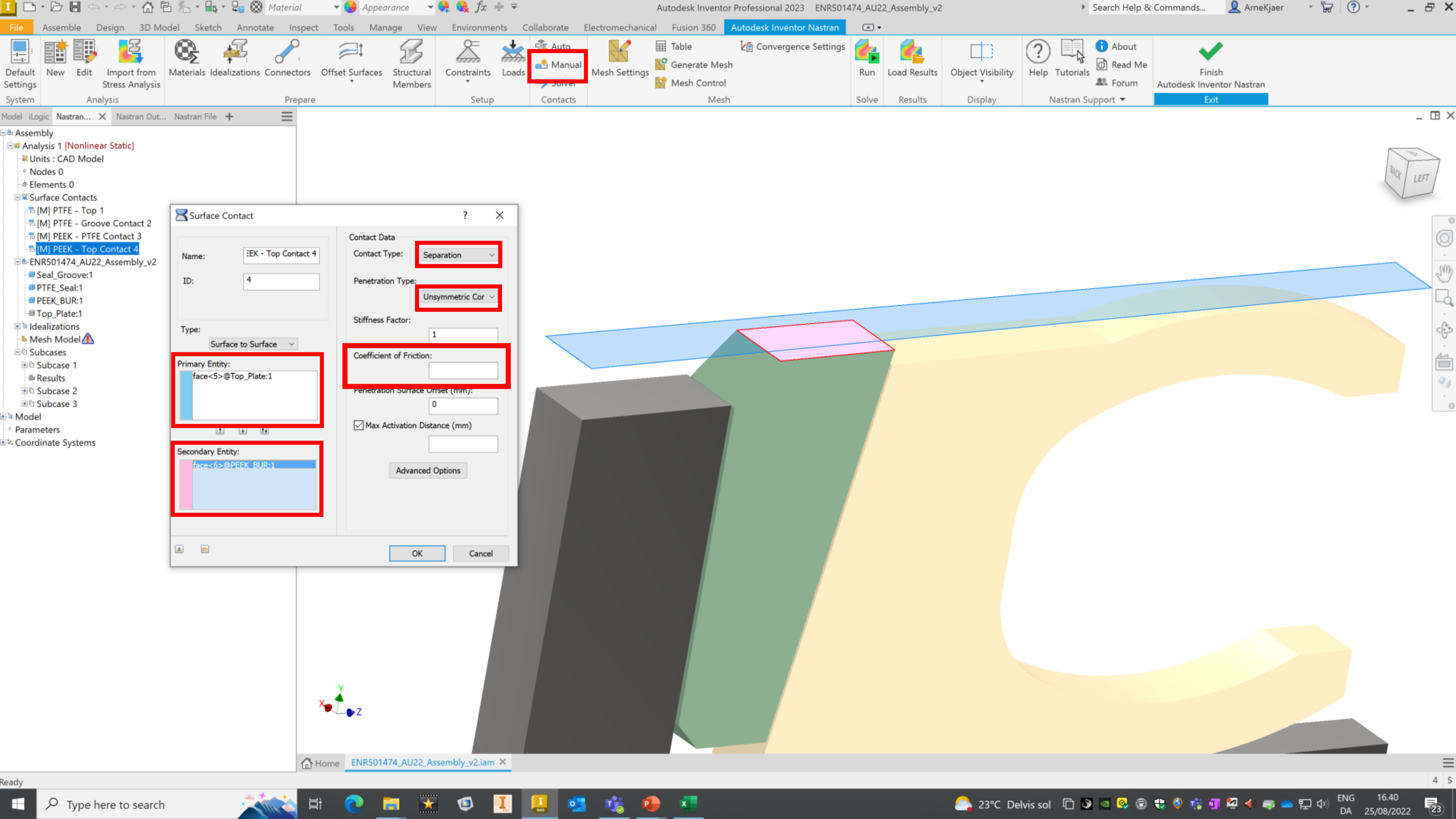
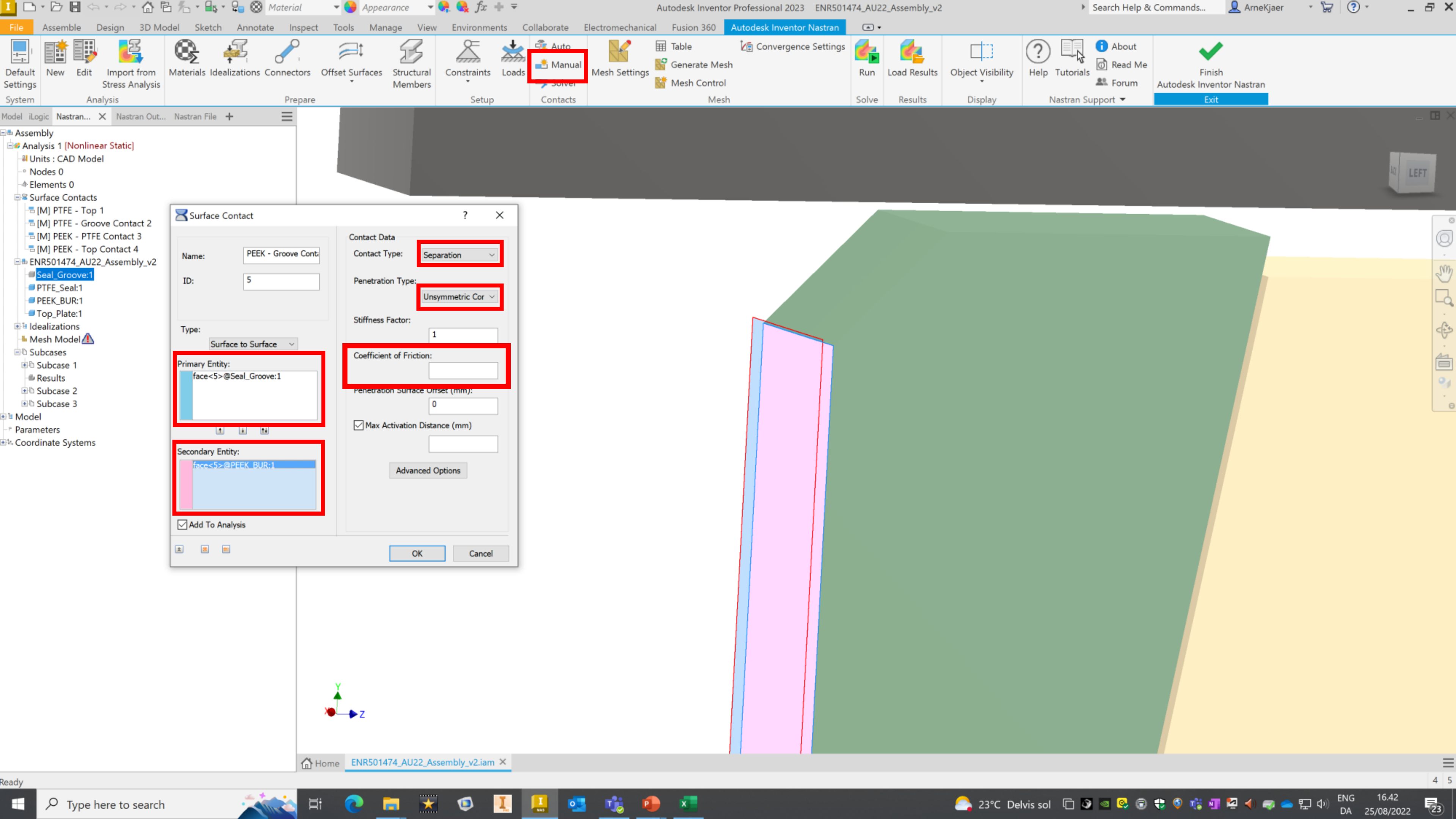
Home
ENR501474_AU22_Assembly_v2.iam
Ready



Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
Surface Contacts
[M] PTFE - Top 1
[M] PTFE - Groove Contact 2
[M] PEEK - PTFE Contact 3
ENR501474_AU22_Assembly_v2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Subcases
Subcase 1
Results
Subcase 2
Subcase 3
Model
Parameters
Coordinate Systems
Surface Contact
Name: PEEK - PTFE Contac
ID: 3
Type: Surface to Surface
Primary Entity: face<3>@PEEK_BUR:1
Secondary Entity: face<4>@PTFE_Seal:1
Contact Data
Contact Type: Separation
Penetration Type: Unsymmetric Cor
Stiffness Factor: 1
Coefficient of Friction:
Penetration Surface Offset (mm): 0
Max Activation Distance (mm)
Advanced Options
OK
Cancel
ENR501474_AU22_Assembly_v2.iam
Ready


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
Surface Contacts
[M] PTFE - Top 1
[M] PTFE - Groove Contact 2
[M] PEEK - PTFE Contact 3
[M] PEEK - Top Contact 4
ENR501474_AU22_Assembly_v2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Subcases
Subcase 1
Results
Subcase 2
Subcase 3
Model
Parameters
Coordinate Systems
Surface Contact
Name:
ID:
4
Type:
Surface to Surface
Primary Entity:
face<5>@Top_Plate:1
Secondary Entity:
face<6>@PEEK_BUR:1
Contact Data
Contact Type:
Separation
Penetration Type:
Unsymmetric Cor
Stiffness Factor:
1
Coefficient of Friction:
Penetration Surface Offset (mm):
0
Max Activation Distance (mm)
Advanced Options
OK
Cancel
Home
ENR501474_AU22_Assembly_v2.iam
Ready



Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
Surface Contacts
[M] PTFE - Top 1
[M] PTFE - Groove Contact 2
[M] PEEK - PTFE Contact 3
[M] PEEK - Top Contact 4
ENR501474_AU22_Assembly_v2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Subcases
Subcase 1
Results
Subcase 2
Subcase 3
Model
Parameters
Coordinate Systems
Surface Contact
Name: PEEK - Groove Conta
ID: 5
Type: Surface to Surface
Primary Entity: face<5>@Seal_Groove:1
Secondary Entity: face<5>@PEEK_BUR:1
Add To Analysis
Contact Data
Contact Type: Separation
Penetration Type: Unsymmetric Cor
Stiffness Factor: 1
Coefficient of Friction:
Penetration Surface Offset (mm): 0
Max Activation Distance (mm)
Advanced Options
OK
Cancel
LEFT
Home
ENR501474_AU22_Assembly_v2.iam
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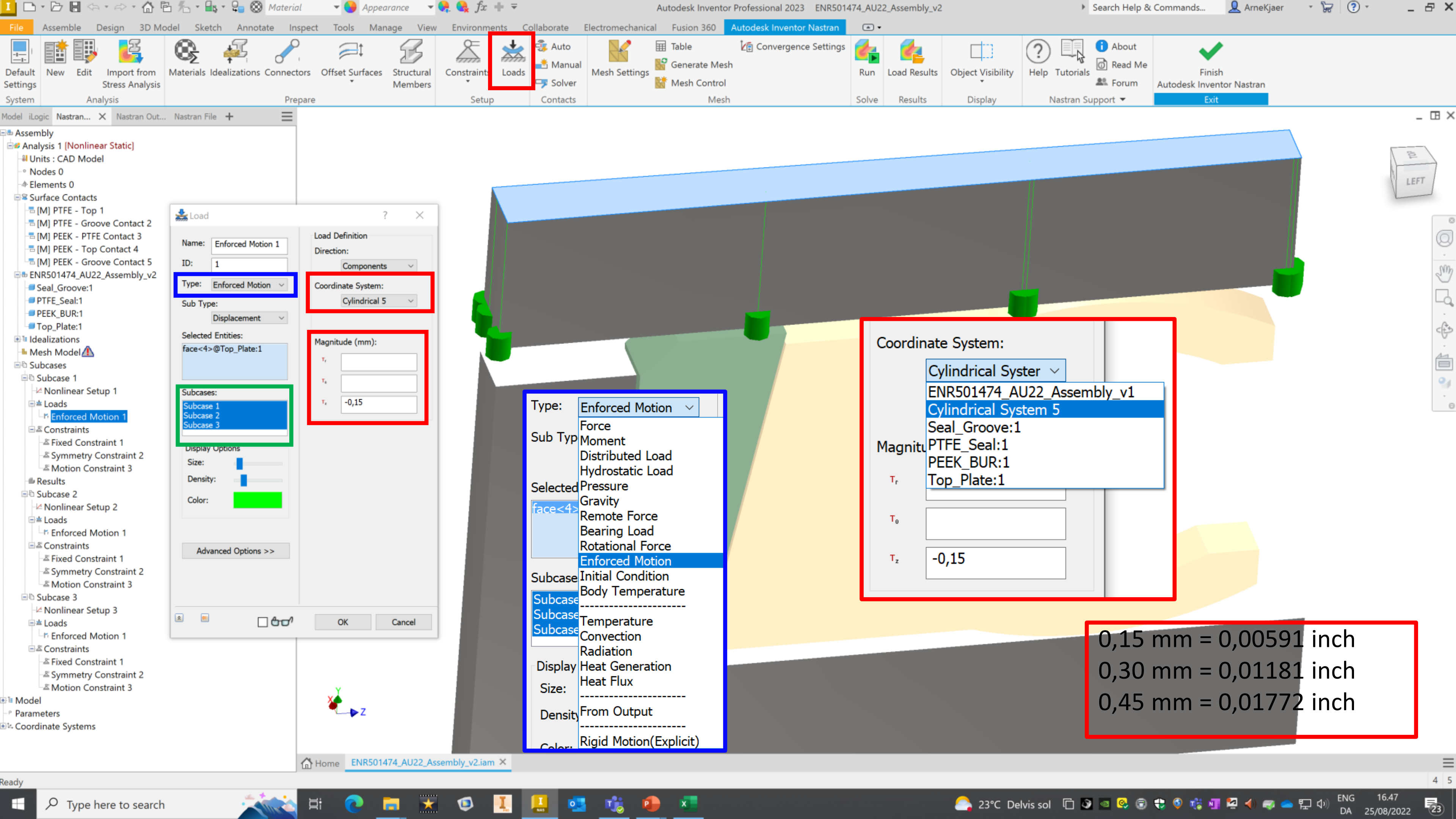
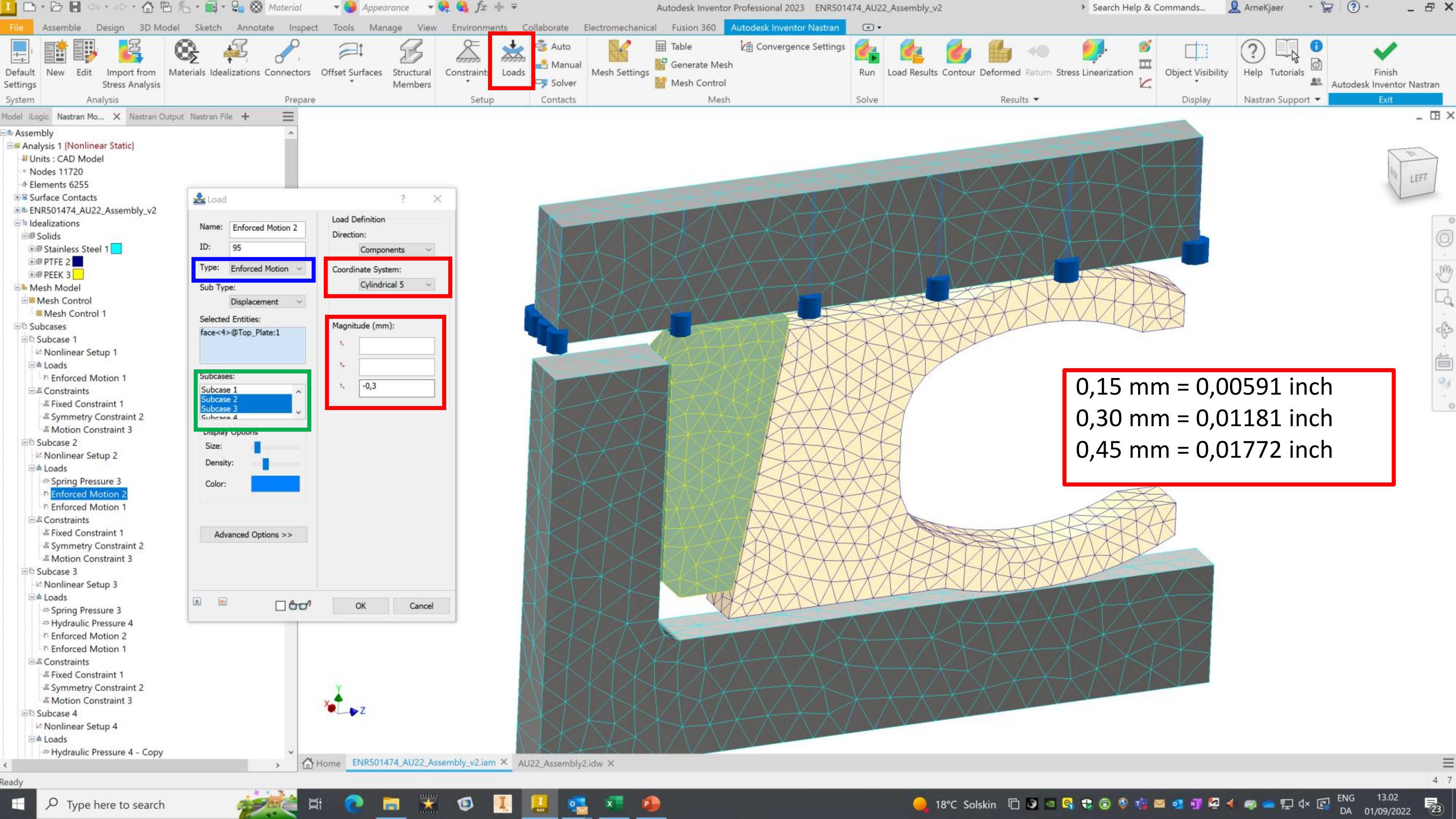
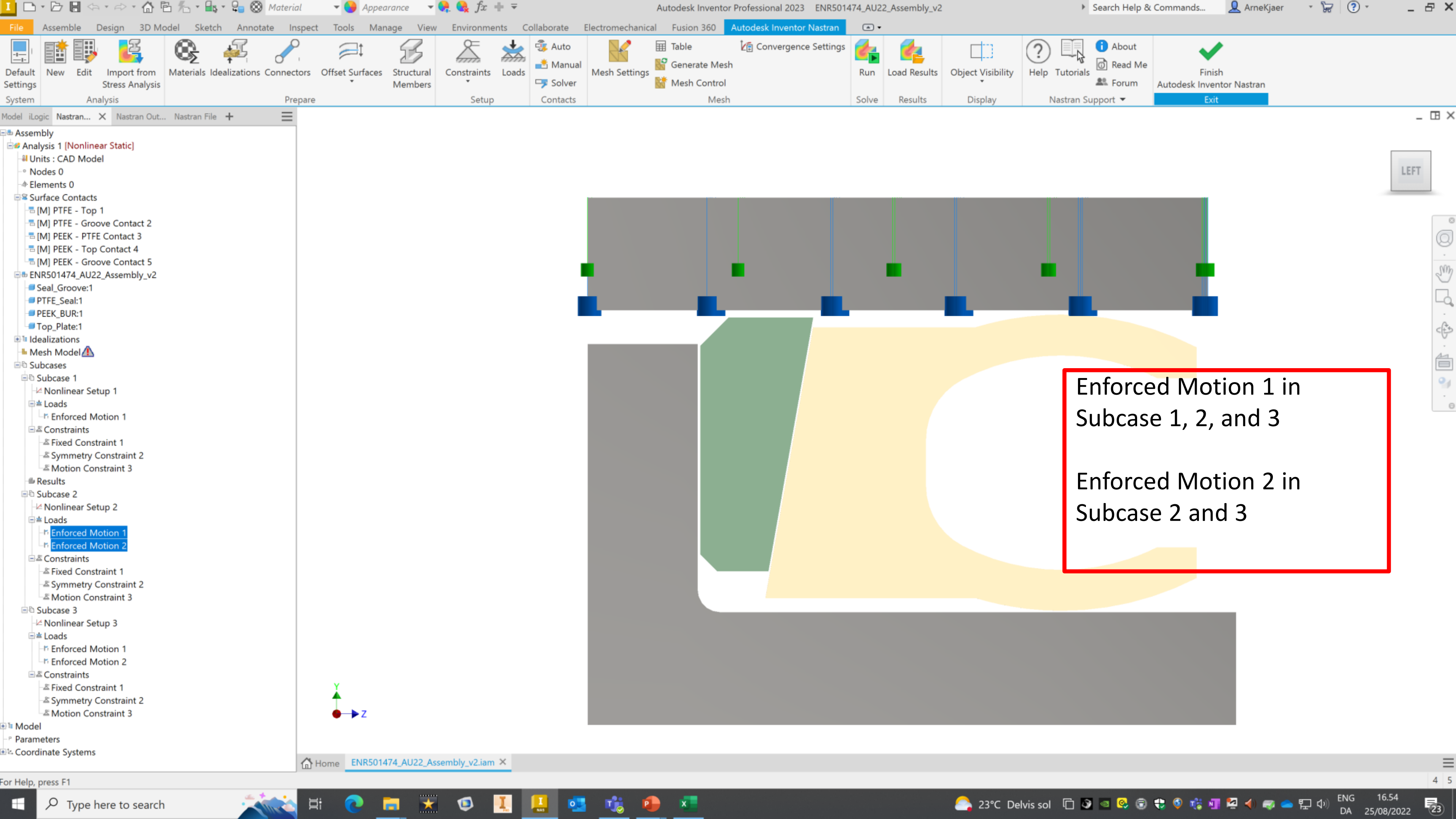
Loads

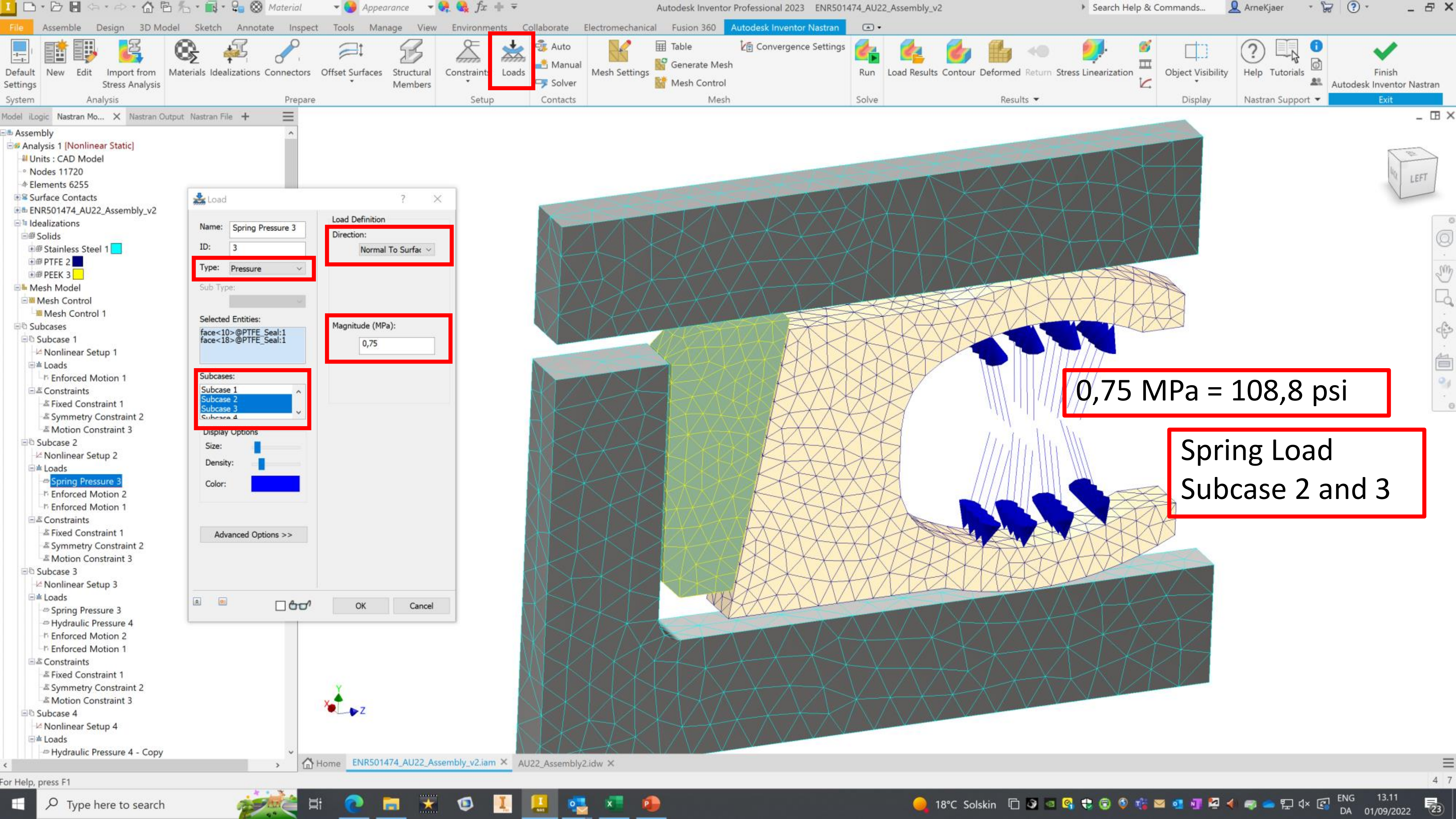


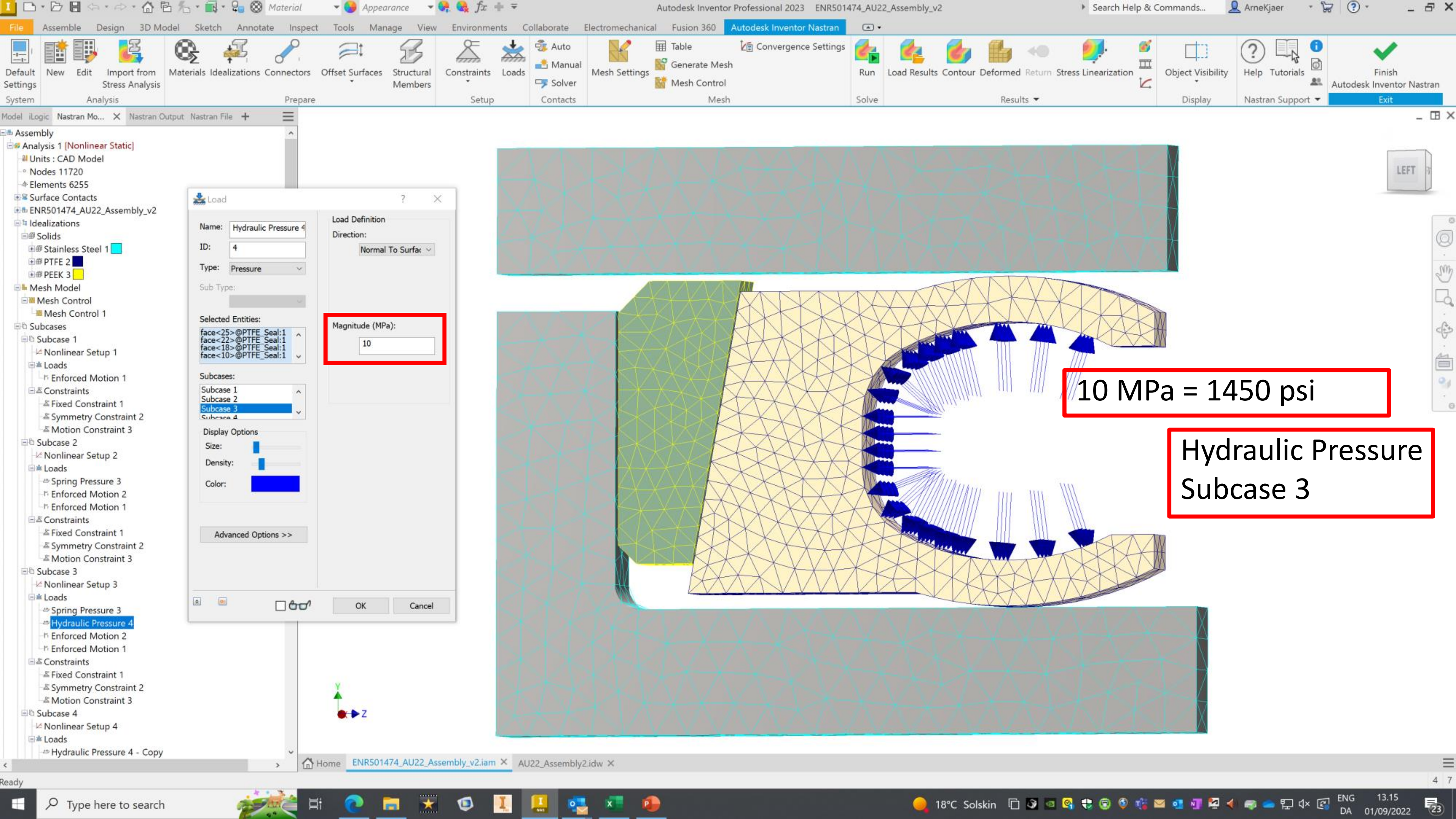
Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Autodesk Inventor Nastran
Loads
Load
Name: Enforced Motion 1
ID: 1
Type: Enforced Motion
Sub Type: Displacement
Selected Entities: face<4>@Top_Plate:1
Subcases: Subcase 1 Subcase 2 Subcase 3
Load Definition
Direction: Components
Coordinate System: Cylindrical 5
Magnitude (mm):
-0,15
Advanced Options >>
OK
Cancel
Type: Enforced Motion
Force
Moment
Distributed Load
Hydrostatic Load
Pressure
Gravity
Remote Force
Bearing Load
Rotational Force
Enforced Motion
Initial Condition
Body Temperature
Temperature
Convection
Radiation
Heat Generation
Heat Flux
From Output
Rigid Motion(Explicit)
Coordinate System:
Cylindrical Syster
ENR501474_AU22_Assembly_v1
Cylindrical System 5
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
-0,15
0,15 mm = 0,00591 inch
0,30 mm = 0,01181 inch
0,45 mm = 0,01772 inch


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Load
Name: Enforced Motion 2
ID: 95
Type: Enforced Motion
Sub Type: Displacement
Selected Entities:
face<4>@Top_Plate:1
Subcases:
Subcase 1
Subcase 2
Subcase 3
Load Definition
Direction:
Components
Coordinate System:
Cylindrical 5
Magnitude (mm):
-0,3
Advanced Options >>
OK
Cancel
0,15 mm = 0,00591 inch
0,30 mm = 0,01181 inch
0,45 mm = 0,01772 inch



Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 0
Elements 0
Surface Contacts
[M] PTFE - Top 1
[M] PTFE - Groove Contact 2
[M] PEEK - PTFE Contact 3
[M] PEEK - Top Contact 4
[M] PEEK - Groove Contact 5
ENR501474_AU22_Assembly_v2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Results
Subcase 2
Nonlinear Setup 2
Loads
Enforced Motion 1
Enforced Motion 2
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Enforced Motion 1
Enforced Motion 2
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Model
Parameters
Coordinate Systems
Enforced Motion 1 in Subcase 1, 2, and 3
Enforced Motion 2 in Subcase 2 and 3


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Load
Name: Spring Pressure 3
ID: 3
Type: Pressure
Sub Type:
Selected Entities:
face<10>@PTFE_Seal:1
face<18>@PTFE_Seal:1
Subcases:
Subcase 1
Subcase 2
Subcase 3
Display Options
Size:
Density:
Color:
Advanced Options >>
Load Definition
Direction:
Normal To Surfac
Magnitude (MPa):
0,75
OK
Cancel
0,75 MPa = 108,8 psi
Spring Load
Subcase 2 and 3


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Autodesk Inventor Nastran
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Load
Name: Hydraulic Pressure 4
ID: 4
Type: Pressure
Sub Type:
Selected Entities:
face<25>@PTFE_Seal:1
face<22>@PTFE_Seal:1
face<18>@PTFE_Seal:1
face<10>@PTFE_Seal:1
Subcases:
Subcase 1
Subcase 2
Subcase 3
Display Options
Size:
Density:
Color:
Advanced Options >>
Load Definition
Direction:
Normal To Surfac
Magnitude (MPa):
10
OK
Cancel
10 MPa = 1450 psi
Hydraulic Pressure
Subcase 3
ENR501474_AU22_Assembly_v2.iam
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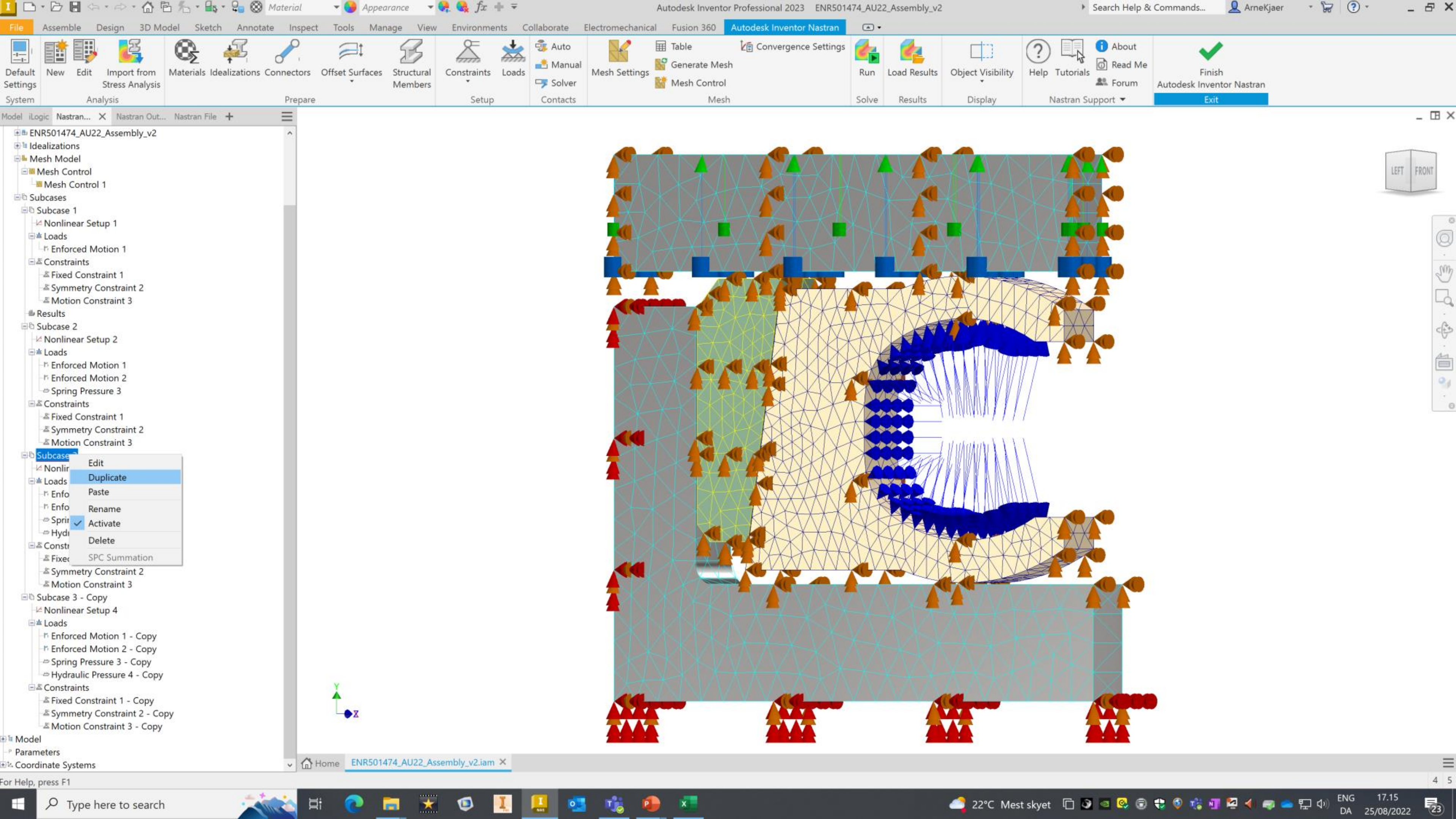
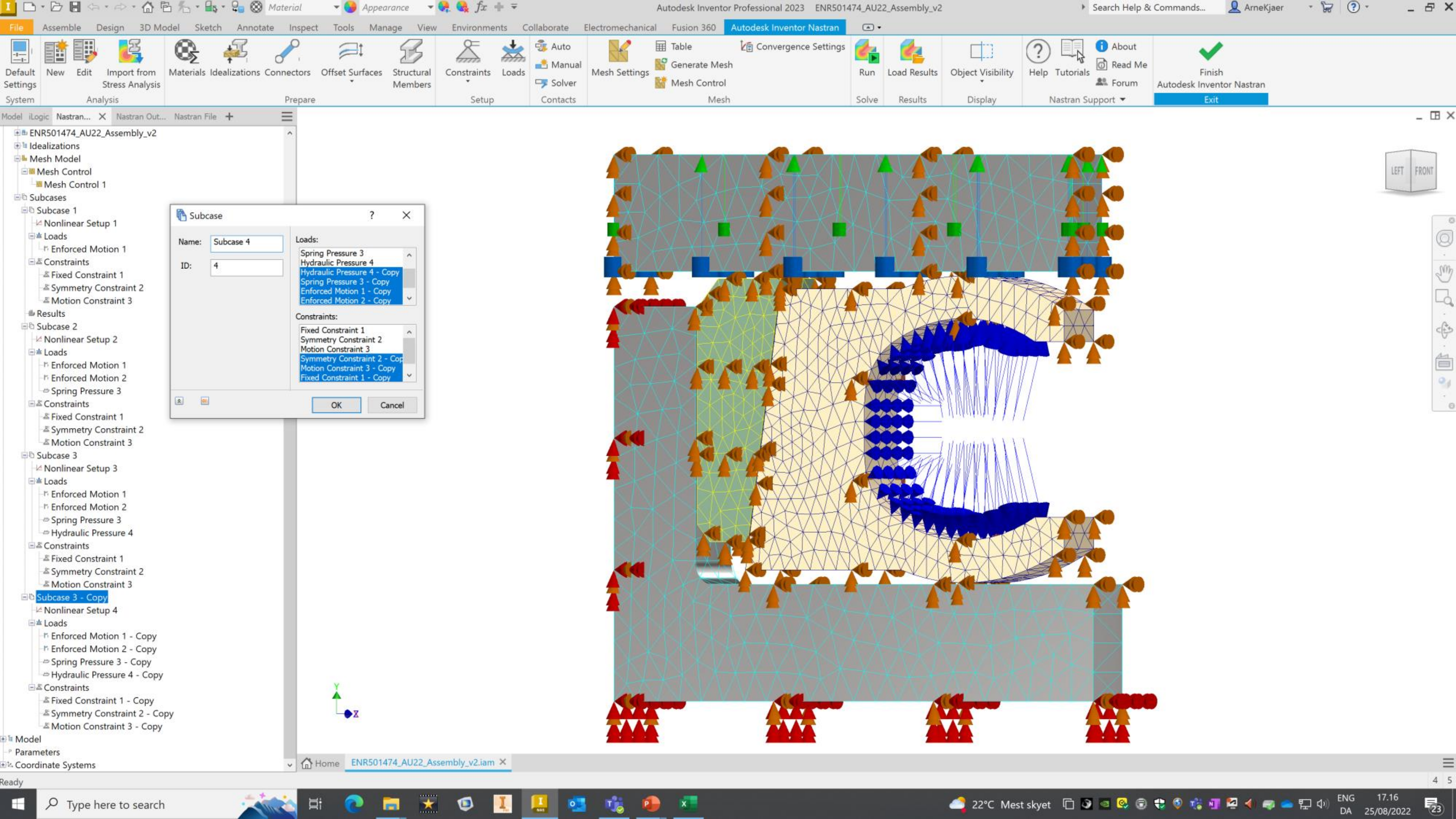
Ready

Subcase 4



Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Search Help & Commands...
ArneKjaer
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Model
iLogic
Nastran...
Nastran Out...
Nastran File
ENR501474_AU22_Assembly_v2
Idealizations
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Results
Subcase 2
Nonlinear Setup 2
Loads
Enforced Motion 1
Enforced Motion 2
Spring Pressure 3
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Edit
Duplicate
Paste
Rename
Activate
Delete
SPC Summation
Symmetry Constraint 2
Motion Constraint 3
Subcase 3 - Copy
Nonlinear Setup 4
Loads
Enforced Motion 1 - Copy
Enforced Motion 2 - Copy
Spring Pressure 3 - Copy
Hydraulic Pressure 4 - Copy
Constraints
Fixed Constraint 1 - Copy
Symmetry Constraint 2 - Copy
Motion Constraint 3 - Copy
Model
Parameters
Coordinate Systems
LEFT
FRONT
Home
ENR501474_AU22_Assembly_v2.iam
For Help, press F1
Type here to search
22°C Mest skyet
ENG
DA
17.15
25/08/2022


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings
New Edit Import from Stress Analysis
Materials Idealizations Connectors Offset Surfaces Structural Members
Constraints Loads
Auto Manual Solver
Mesh Settings
Table Generate Mesh Mesh Control
Convergence Settings
Run Load Results Object Visibility Help Tutorials
About Read Me Forum
Finish Autodesk Inventor Nastran
System Analysis Prepare Setup Contacts Mesh Solve Results Display Nastran Support Exit
Model iLogic Nastran... Nastran Out... Nastran File
ENR501474_AU22_Assembly_v2
Idealizations
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Results
Subcase 2
Nonlinear Setup 2
Loads
Enforced Motion 1
Enforced Motion 2
Spring Pressure 3
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Enforced Motion 1
Enforced Motion 2
Spring Pressure 3
Hydraulic Pressure 4
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3 - Copy
Nonlinear Setup 4
Loads
Enforced Motion 1 - Copy
Enforced Motion 2 - Copy
Spring Pressure 3 - Copy
Hydraulic Pressure 4 - Copy
Constraints
Fixed Constraint 1 - Copy
Symmetry Constraint 2 - Copy
Motion Constraint 3 - Copy
Model
Parameters
Coordinate Systems
Subcase
Name: Subcase 4
ID: 4
Loads:
Spring Pressure 3
Hydraulic Pressure 4
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Enforced Motion 1 - Copy
Enforced Motion 2 - Copy
Constraints:
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Symmetry Constraint 2 - Cop
Motion Constraint 3 - Copy
Fixed Constraint 1 - Copy
OK Cancel
LEFT FRONT
Home ENR501474_AU22_Assembly_v2.iam
Ready
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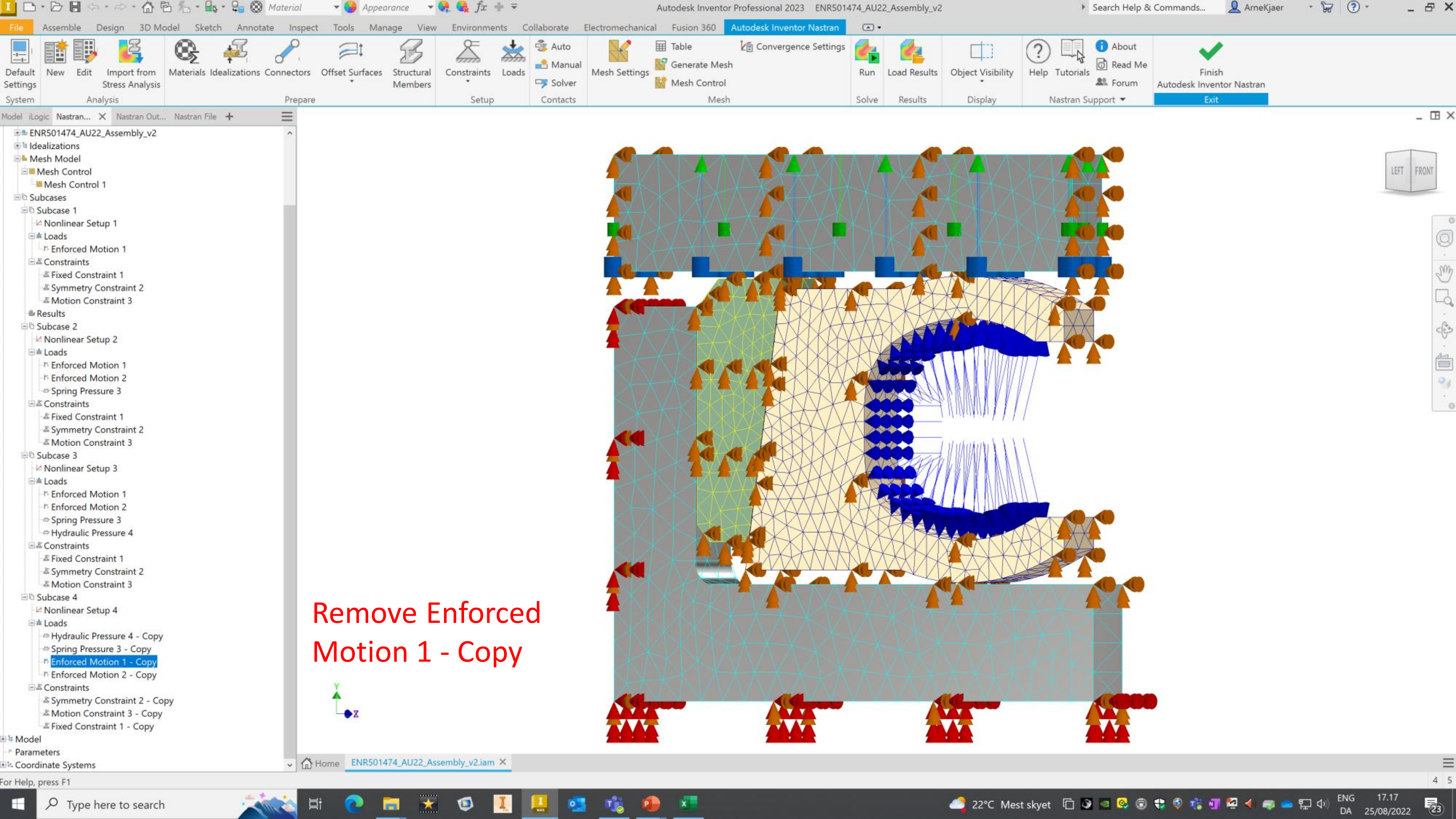
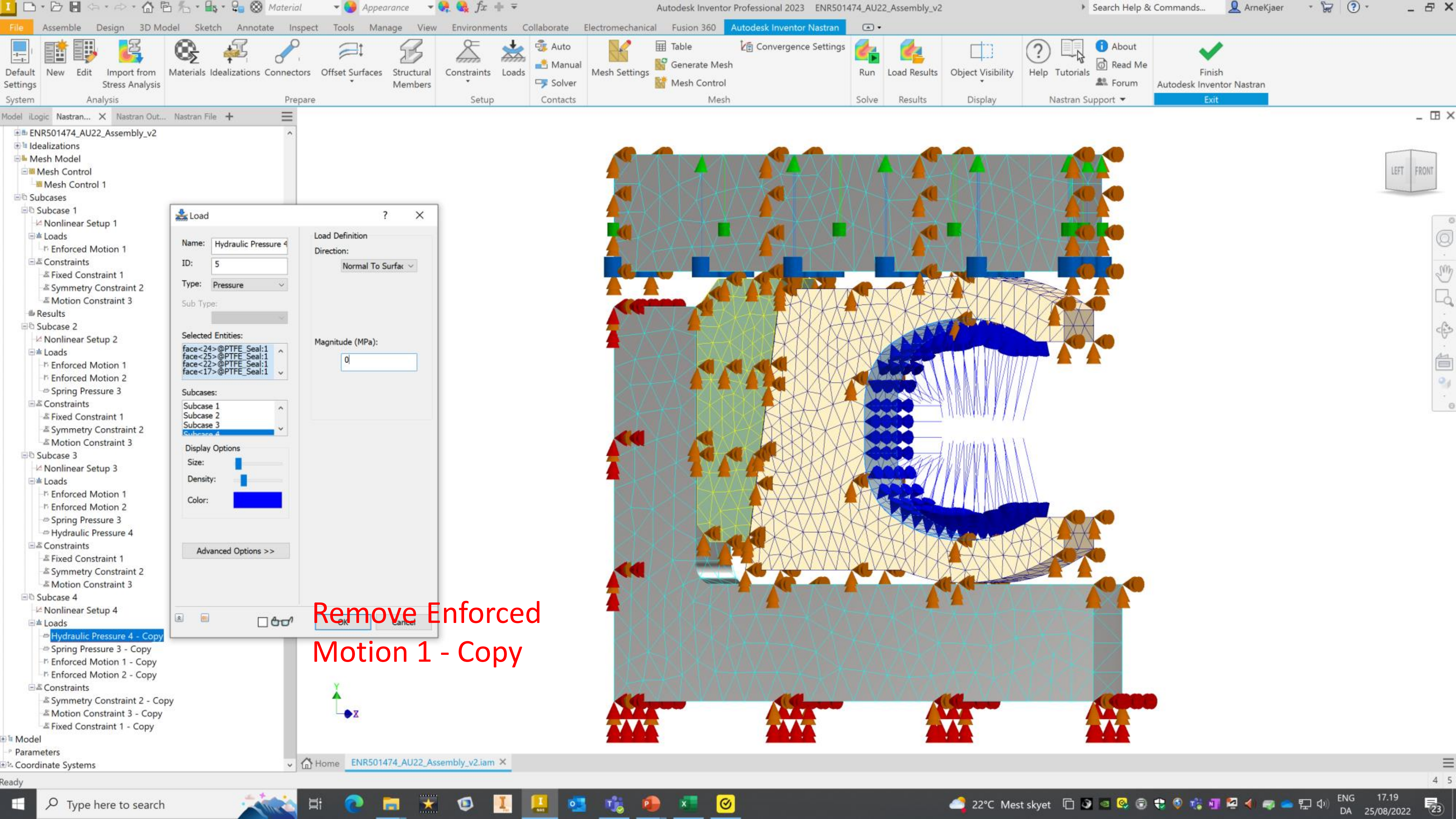
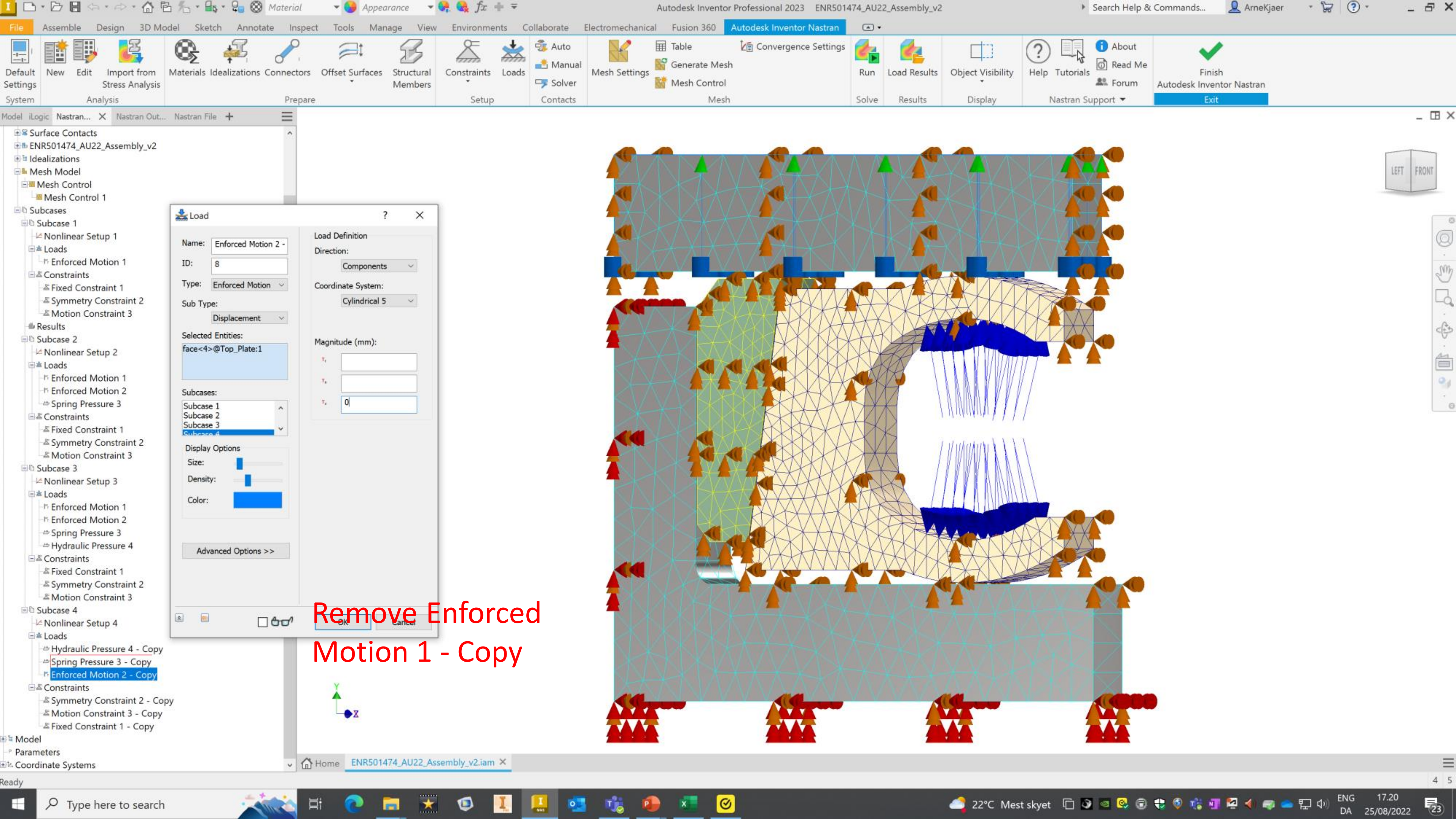


Remove Enforced Motion 1 - Copy

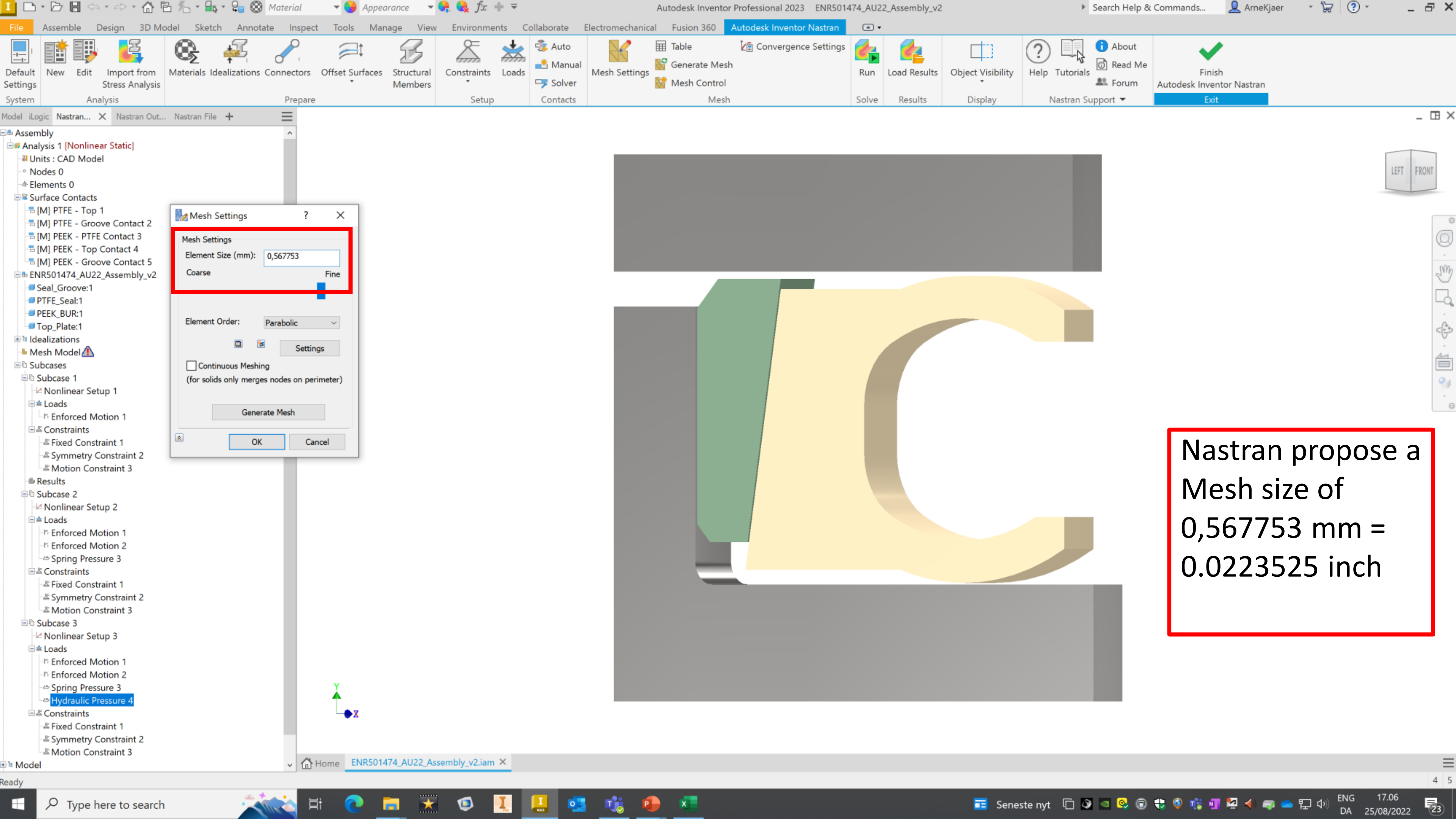


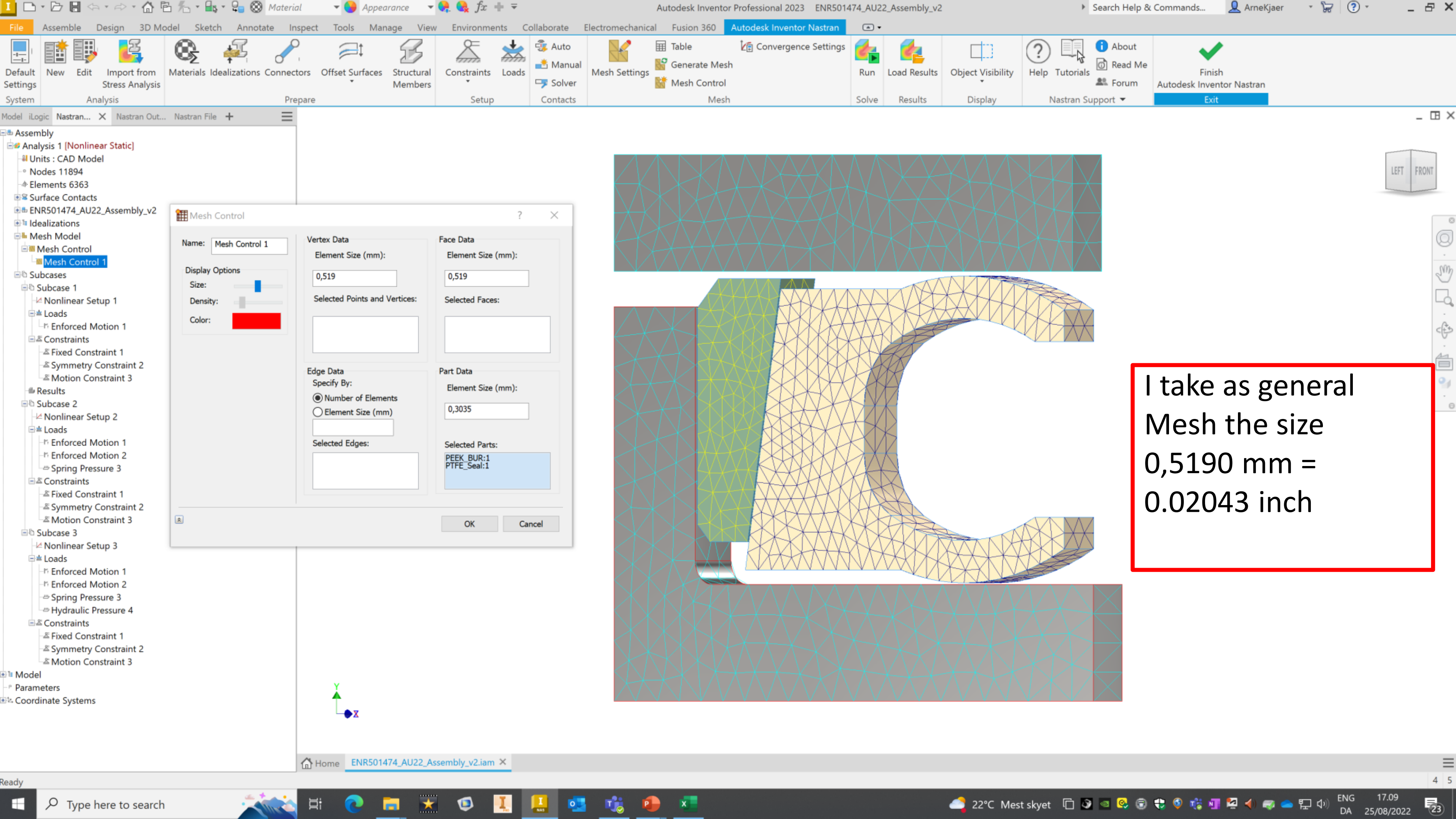
Remove Enforced Motion 1 - Copy



Remove Enforced Motion 1 - Copy

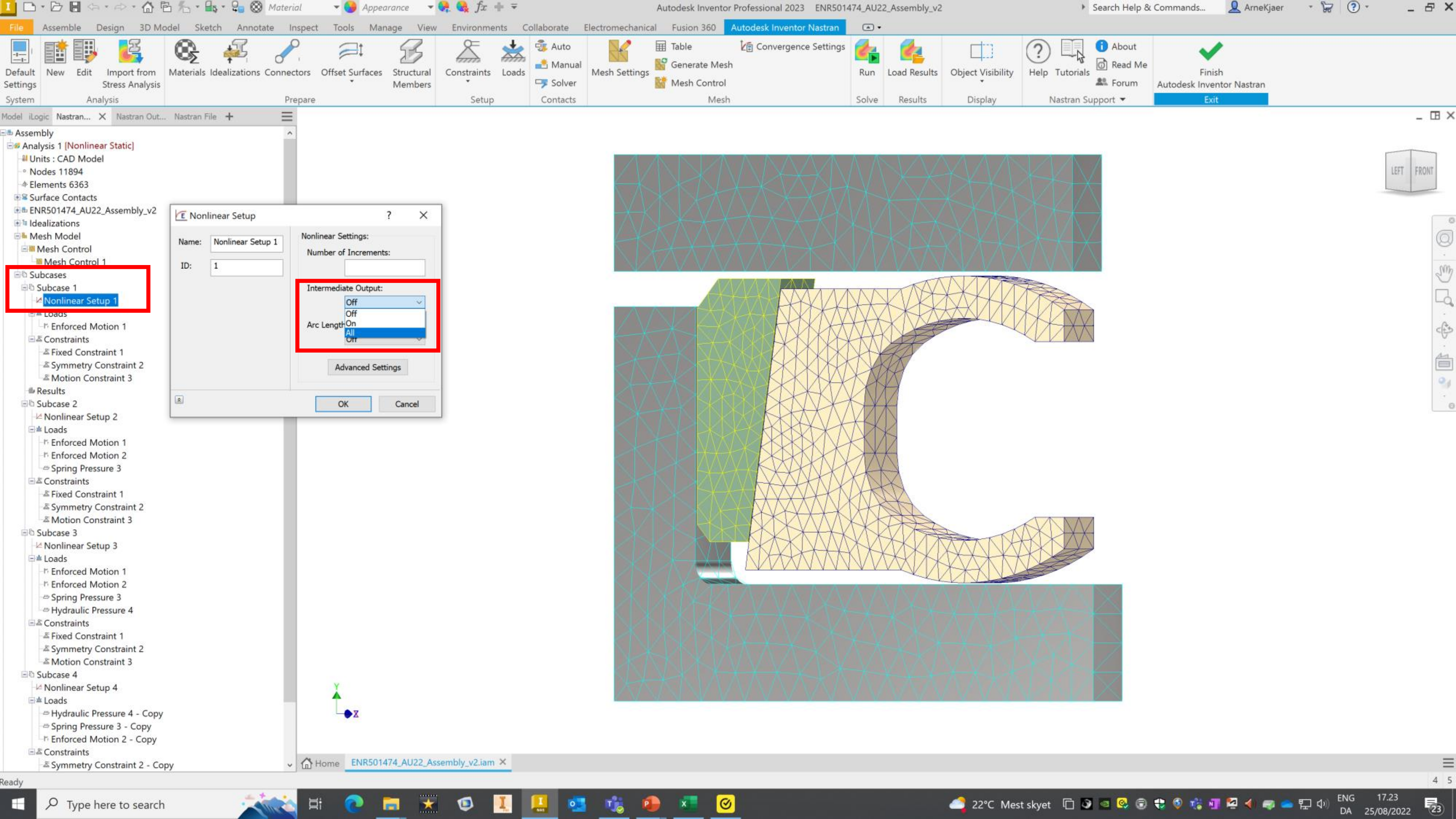
Mesh
Mesh Control


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Autodesk Inventor Nastran
Mesh Settings
Mesh Settings
Element Size (mm):
0,567753
Coarse
Fine
Element Order:
Parabolic
Settings
Continuous Meshing
(for solids only merges nodes on perimeter)
Generate Mesh
OK
Cancel
Analysis 1 [Nonlinear Static]
Surface Contacts
[M] PTFE - Top 1
[M] PTFE - Groove Contact 2
[M] PEEK - PTFE Contact 3
[M] PEEK - Top Contact 4
[M] PEEK - Groove Contact 5
ENR501474_AU22_Assembly_v2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Subcases
Nastran propose a Mesh size of 0,567753 mm = 0.0223525 inch


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Mesh Control
Name: Mesh Control 1
Display Options
Size:
Density:
Color:
Vertex Data
Element Size (mm):
0,519
Selected Points and Vertices:
Face Data
Element Size (mm):
0,519
Selected Faces:
Edge Data
Specify By:
Number of Elements
Element Size (mm)
Selected Edges:
Part Data
Element Size (mm):
0,3035
Selected Parts:
PEEK_BUR:1
PTFE_Seal:1
OK
Cancel
I take as general
Mesh the size
0,5190 mm =
0.02043 inch

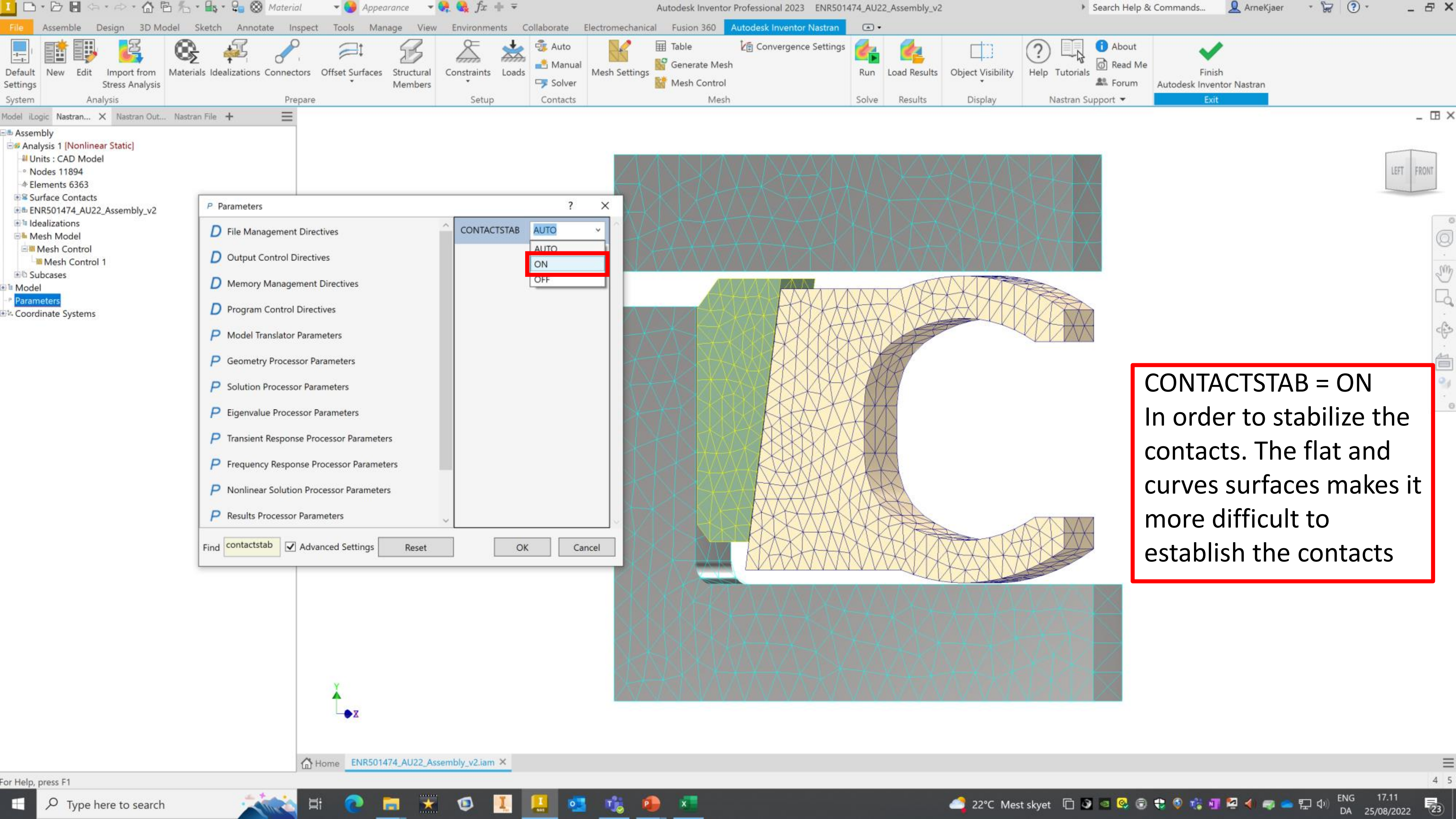
Relative	Mesh	Mesh Control	Nodes	Elements	Max Stress	Wall clock time
100%	0,5190	0,3035	11567	6150	22,4	344,99
100%	0,5190	0,3035	11567	6150	22,25	311,83
500%	0,3035					
175%	0,4307					
150%	0,4534					
125%	0,4818					
120%	0,4884					
110%	0,5028					
100%	**0,5190**	NA	6857	3503	26,54	260,8
90%	0,5376					
80%	0,5591					
75%	0,5712					
50%	0,6539					
25%	0,8239					
15%	0,9768					
10%	1,1182					
5%	1,4088					

Nonlinear Setup



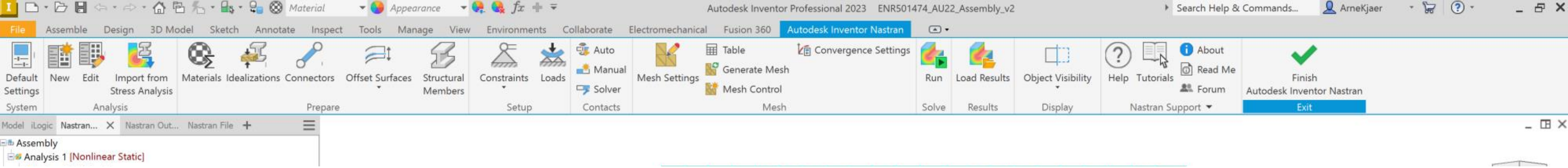
Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11894
Elements 6363
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Results
Subcase 2
Nonlinear Setup 2
Loads
Enforced Motion 1
Enforced Motion 2
Spring Pressure 3
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Enforced Motion 1
Enforced Motion 2
Spring Pressure 3
Hydraulic Pressure 4
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Enforced Motion 2 - Copy
Constraints
Symmetry Constraint 2 - Copy
Nonlinear Setup
Name: Nonlinear Setup 1
ID: 1
Nonlinear Settings:
Number of Increments:
Intermediate Output:
Off
On
All
Arc Length
Advanced Settings
OK
Cancel
Home
ENR501474_AU22_Assembly_v2.iam
Ready

Parameters



CONTACTSTAB = ON

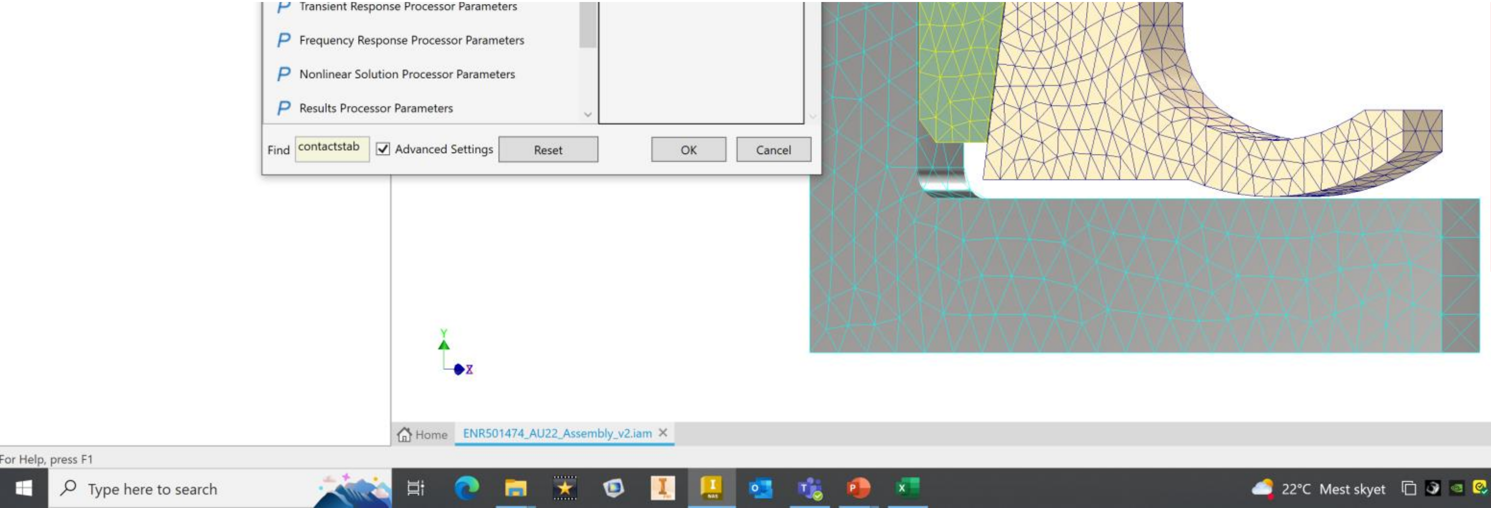
In order to stabilize the contacts. The flat and curves surfaces makes it more difficult to establish the contacts



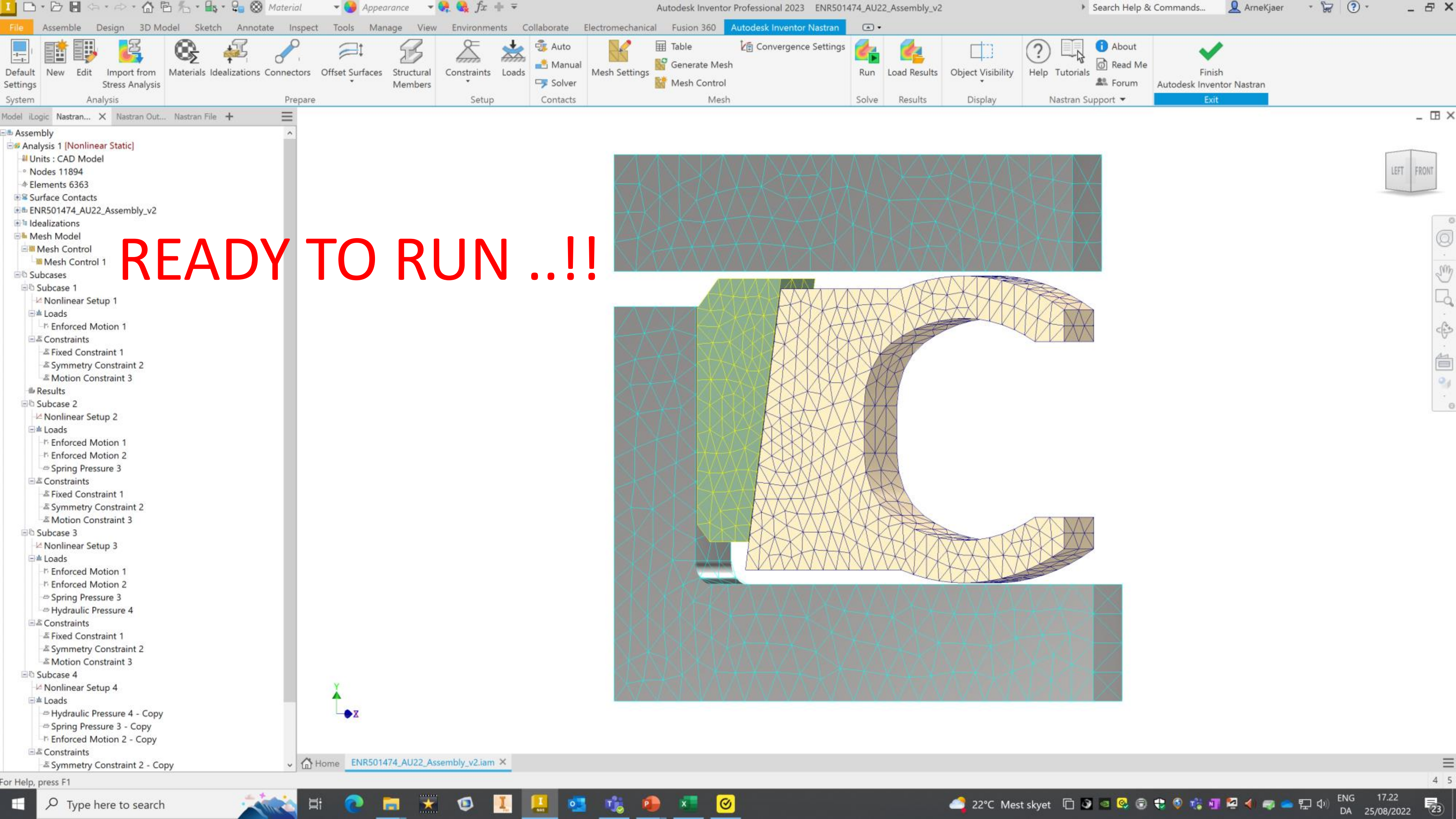
CONTACTSTAB

Description	Type	Default
Surface contact solution stabilization option. When set to ON, will generate stabilization spring stiffness via the model parameters NLKDIAGSET, NLKDIAGAFACT, and NLKDIAGMINAFACT on the contact boundary. The default AUTO setting will automatically detect and stabilize all surface contact in the model with a significant initial gap (i.e., model reference dimension multiplied by 1.0E-04). The stabilization stiffness used can be controlled by specifying a scale factor which is a multiplier to the stabilization stiffness calculated automatically.	Real ON/OFF AUTO	AUTO

Parent topic: Nonlinear Solution Processor Parameters



contacts. The flat and curves surfaces makes it more difficult to establish the contacts


READY TO RUN ..!!
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File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Model
iLogic
Nastran...
Nastran Out...
Nastran File
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11894
Elements 6363
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Results
Subcase 2
Nonlinear Setup 2
Loads
Enforced Motion 1
Enforced Motion 2
Spring Pressure 3
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Enforced Motion 1
Enforced Motion 2
Spring Pressure 3
Hydraulic Pressure 4
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Enforced Motion 2 - Copy
Constraints
Symmetry Constraint 2 - Copy
LEFT
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Home
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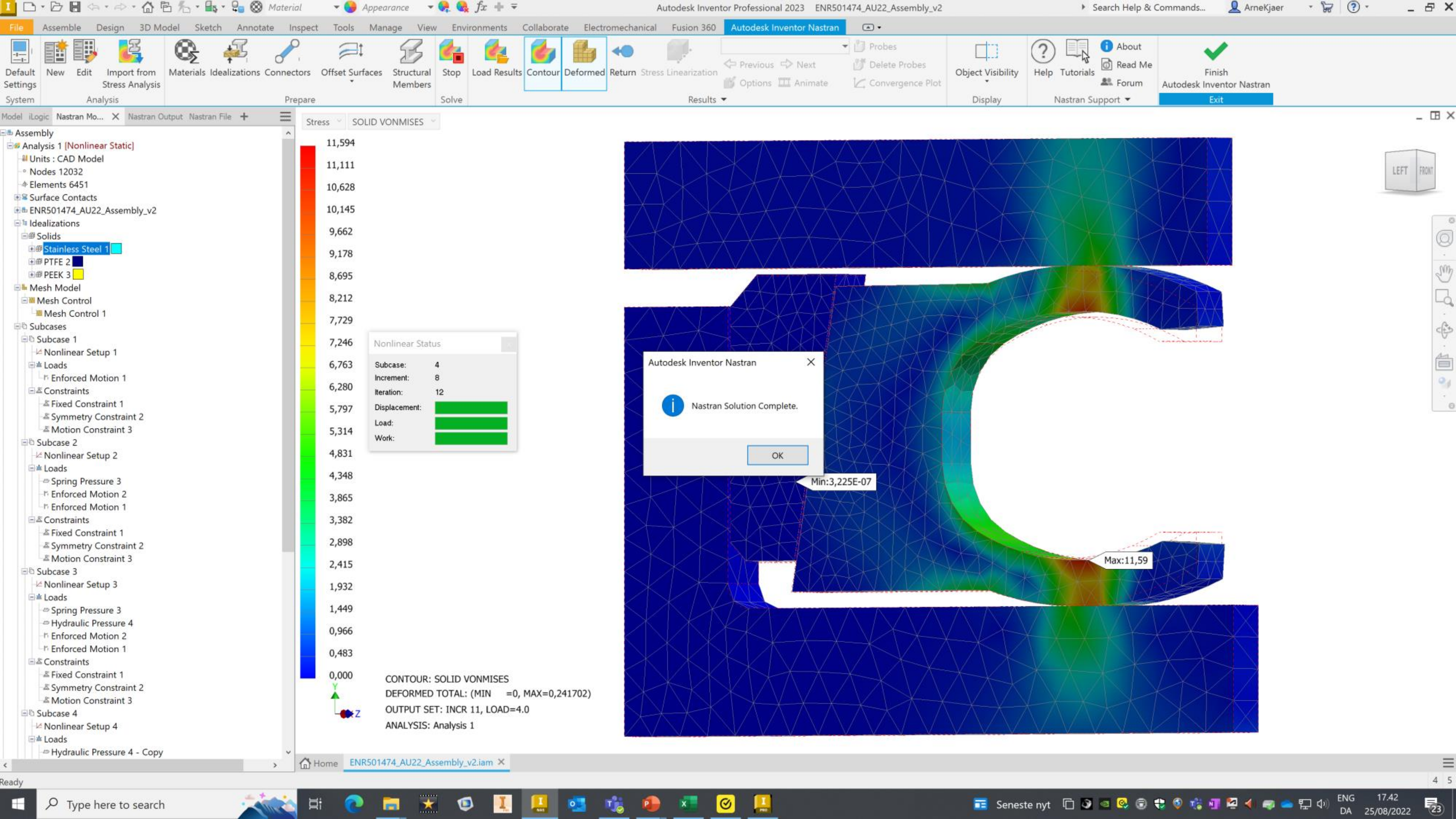
Run the Analysis


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Stop
Load Results
Contour
Deformed
Return
Stress Linearization
Probes
Previous
Next
Delete Probes
Options
Animate
Convergence Plot
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
System
Analysis
Prepare
Solve
Results
Display
Nastran Support
Model
iLogic
Nastran Mo...
Nastran Output
Nastran File
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 12032
Elements 6451
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Stress
SOLID VONMISES
11,594
11,111
10,628
10,145
9,662
9,178
8,695
8,212
7,729
7,246
6,763
6,280
5,797
5,314
4,831
4,348
3,865
3,382
2,898
2,415
1,932
1,449
0,966
0,483
0,000
Nonlinear Status
Subcase: 4
Increment: 8
Iteration: 12
Displacement:
Load:
Work:
Autodesk Inventor Nastran
Nastran Solution Complete.
OK
Min:3,225E-07
Max:11,59
LEFT
FRONT
CONTOUR: SOLID VONMISES
DEFORMED TOTAL: (MIN =0, MAX=0,241702)
OUTPUT SET: INCR 11, LOAD=4.0
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Home
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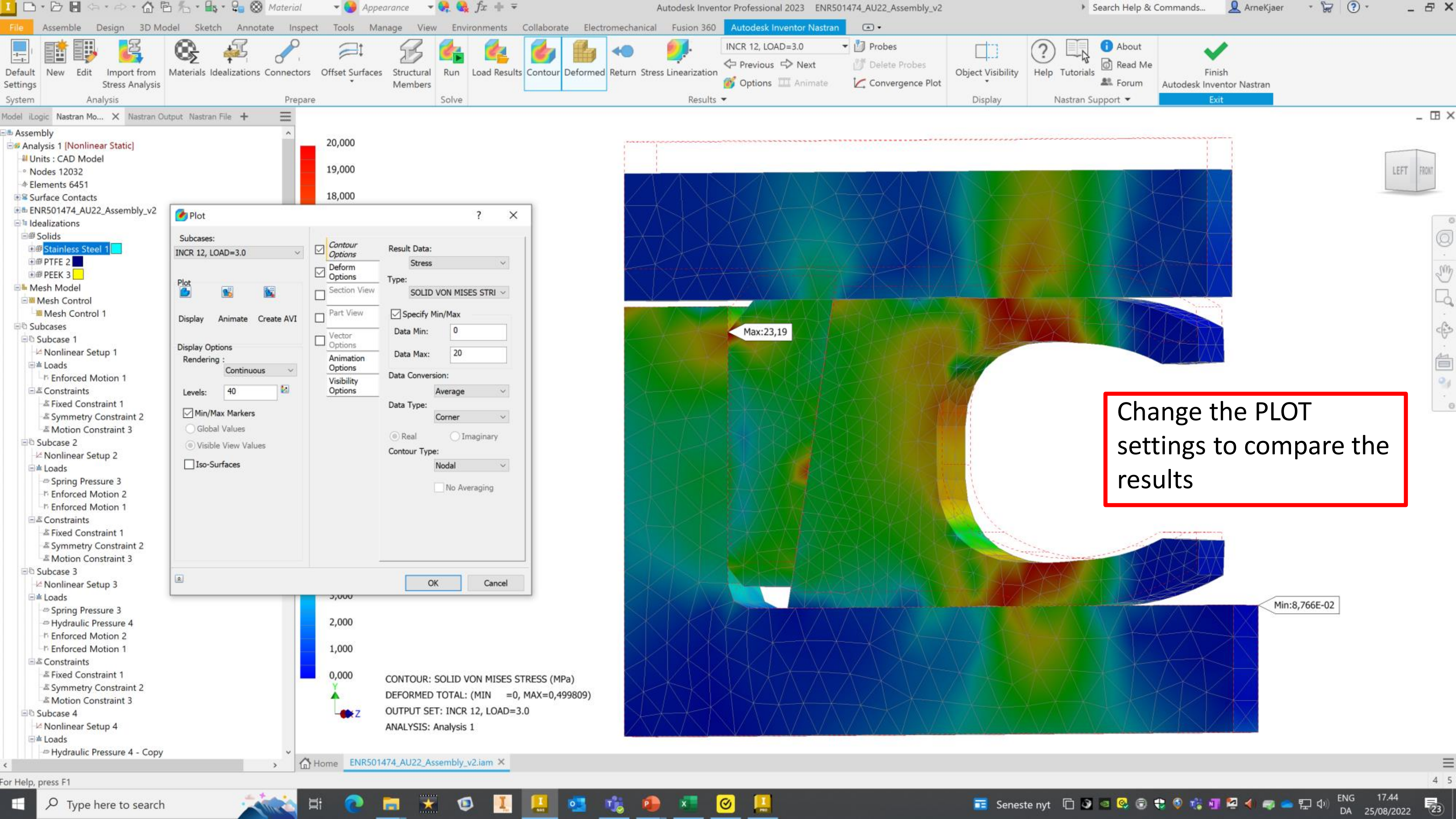
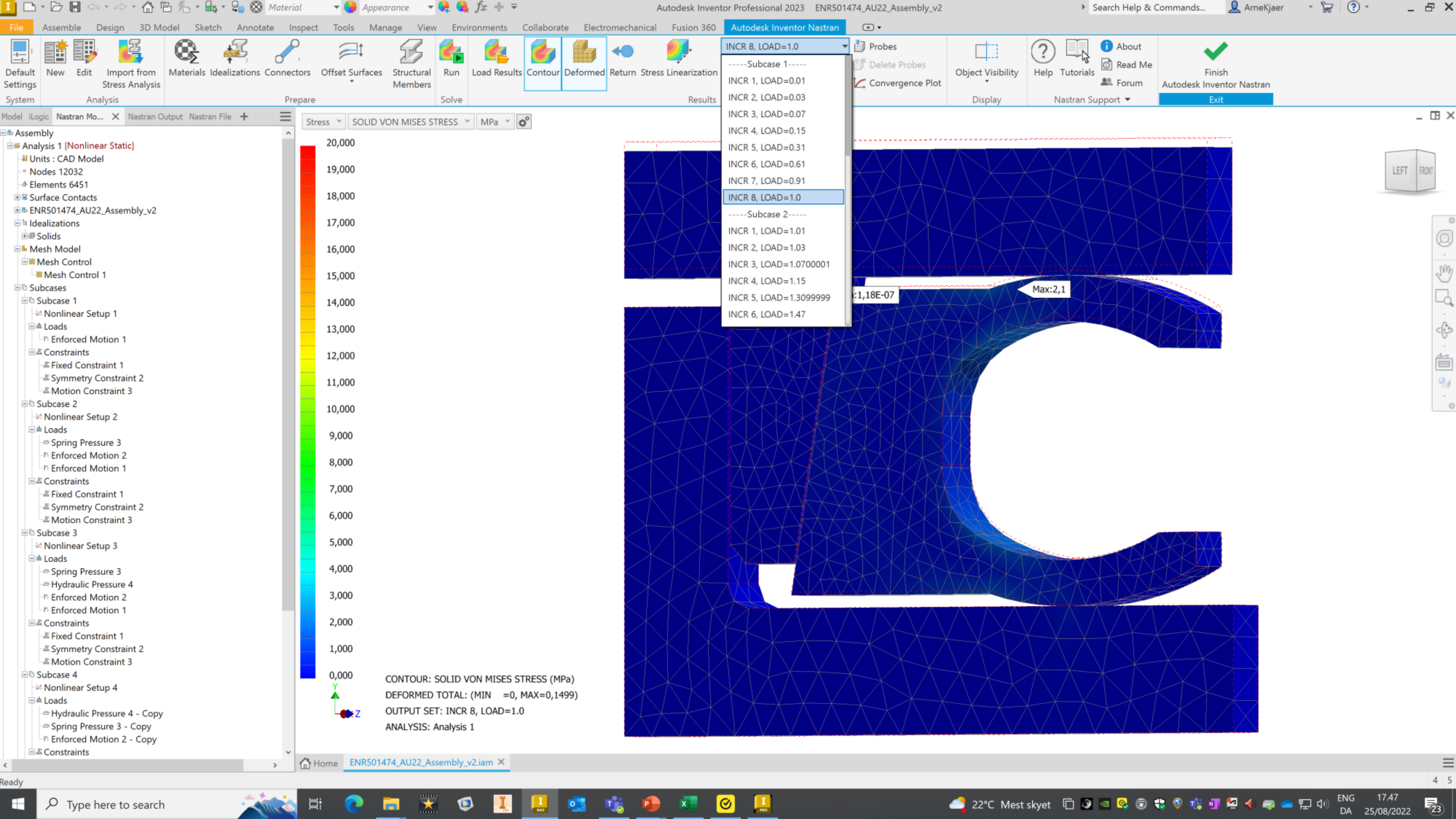


Change the PLOT settings to compare the results


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Run
Load Results
Contour
Deformed
Return
Stress Linearization
Probes
Delete Probes
Convergence Plot
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
INCR 8, LOAD=1.0
-----Subcase 1-----
INCR 1, LOAD=0.01
INCR 2, LOAD=0.03
INCR 3, LOAD=0.07
INCR 4, LOAD=0.15
INCR 5, LOAD=0.31
INCR 6, LOAD=0.61
INCR 7, LOAD=0.91
INCR 8, LOAD=1.0
-----Subcase 2-----
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INCR 2, LOAD=1.03
INCR 3, LOAD=1.0700001
INCR 4, LOAD=1.15
INCR 5, LOAD=1.3099999
INCR 6, LOAD=1.47
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SOLID VON MISES STRESS
MPa
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 12032
Elements 6451
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
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Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Enforced Motion 2 - Copy
Constraints
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3,000
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0,000
Max:2,1
:1,18E-07
CONTOUR: SOLID VON MISES STRESS (MPa)
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ENR501474_AU22_Assembly_v2.iam
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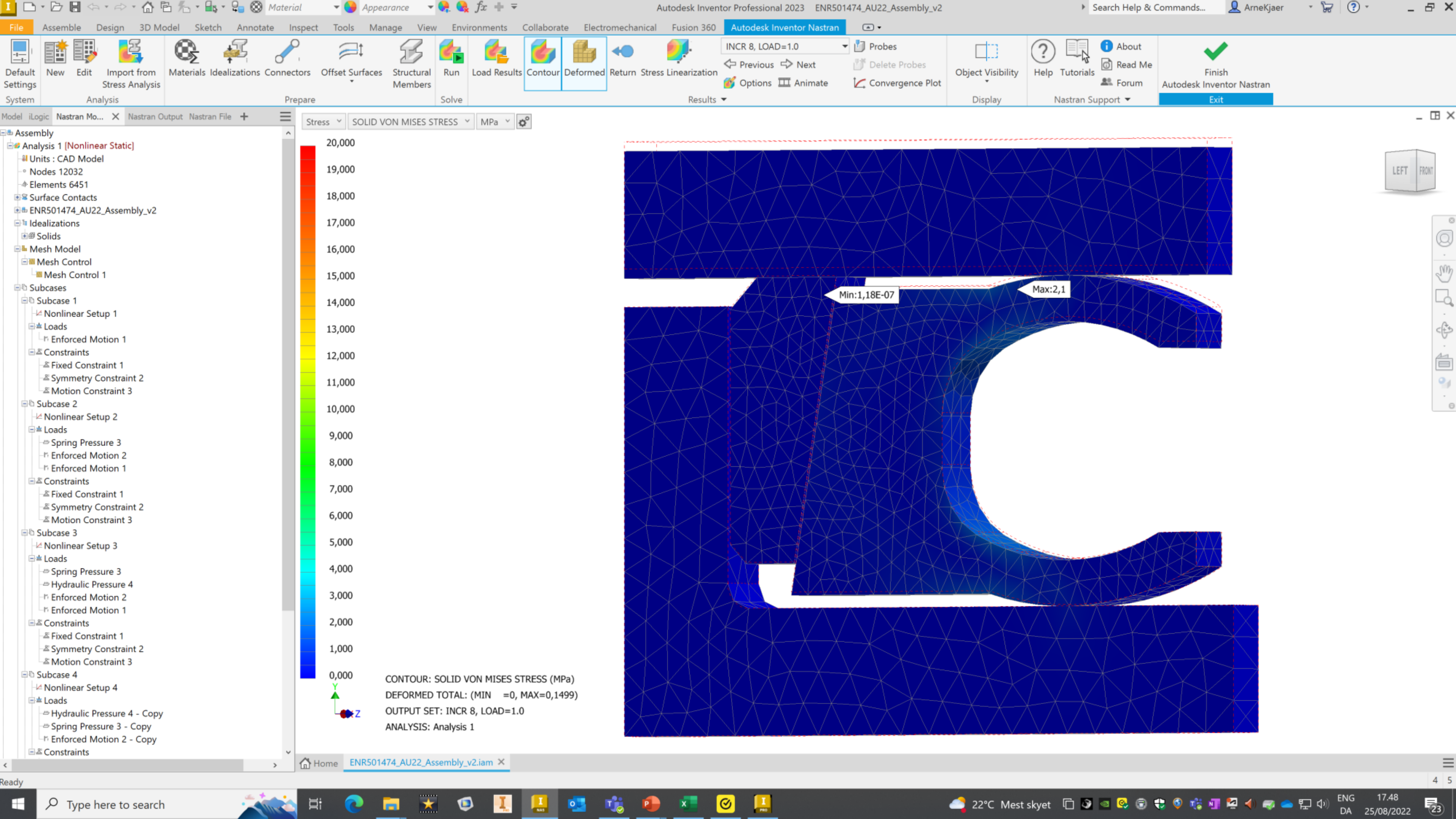
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Default Settings New Edit Import from Stress Analysis Materials Idealizations Connectors Offset Surfaces Structural Members Run Load Results Contour Deformed Return Stress Linearization
INCR 8, LOAD=1.0
Probes Delete Probes Convergence Plot Previous Next Options Animate
Object Visibility Help Tutorials About Read Me Forum
Finish Autodesk Inventor Nastran
Exit
System Analysis Prepare Solve Results Display Nastran Support
Model iLogic Nastran Mo... Nastran Output Nastran File
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 12032
Elements 6451
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
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Spring Pressure 3 - Copy
Enforced Motion 2 - Copy
Constraints
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Min:1,18E-07
Max:2,1
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,1499)
OUTPUT SET: INCR 8, LOAD=1.0
ANALYSIS: Analysis 1
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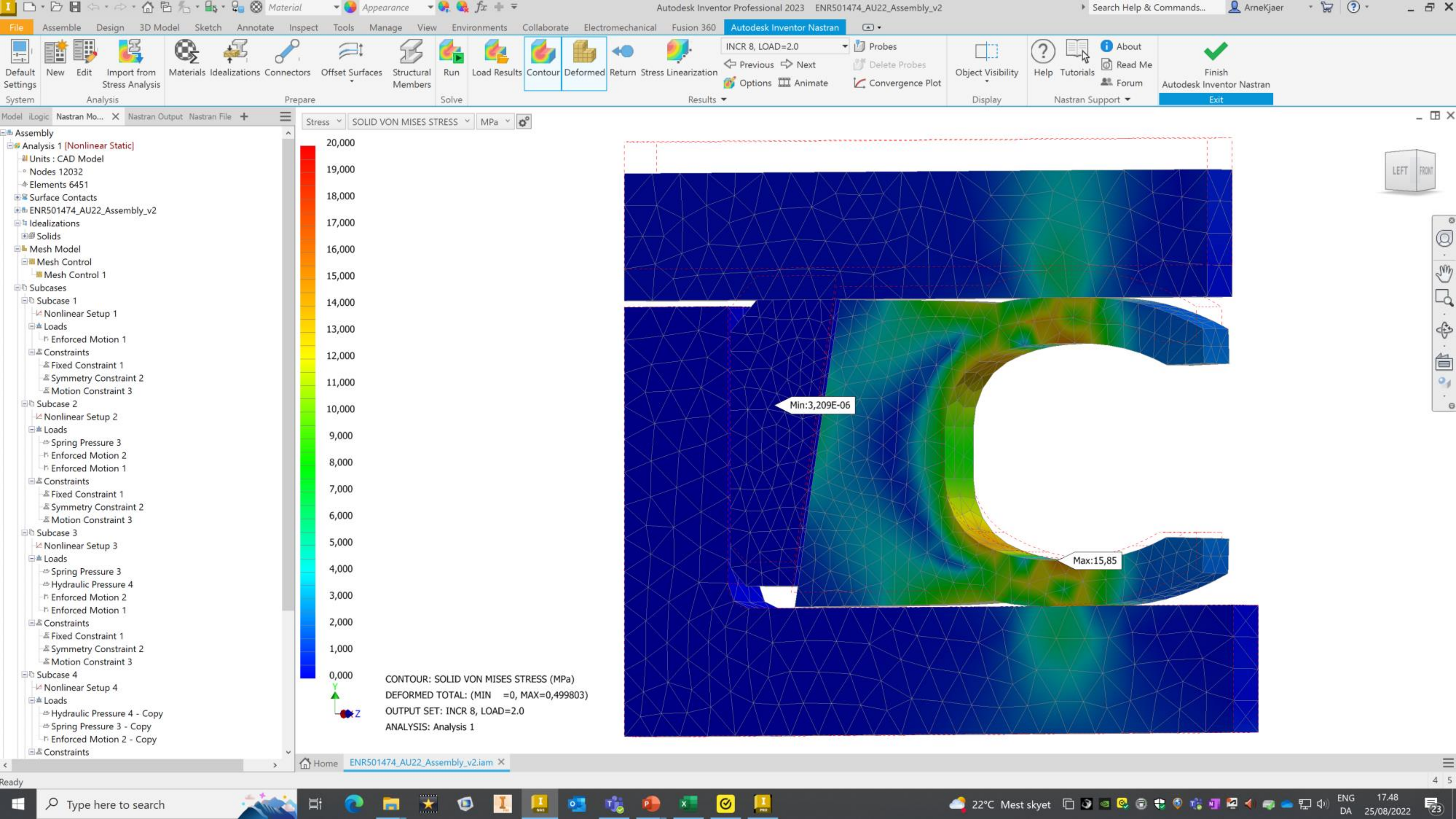
Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Run
Load Results
Contour
Deformed
Return
Stress Linearization
INCR 8, LOAD=2.0
Previous
Next
Options
Animate
Probes
Delete Probes
Convergence Plot
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
System
Analysis
Prepare
Solve
Results
Display
Nastran Support
Model iLogic Nastran Mo... Nastran Output Nastran File
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 12032
Elements 6451
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
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Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Enforced Motion 2 - Copy
Constraints
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Min:3,209E-06
Max:15,85
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Home ENR501474_AU22_Assembly_v2.iam
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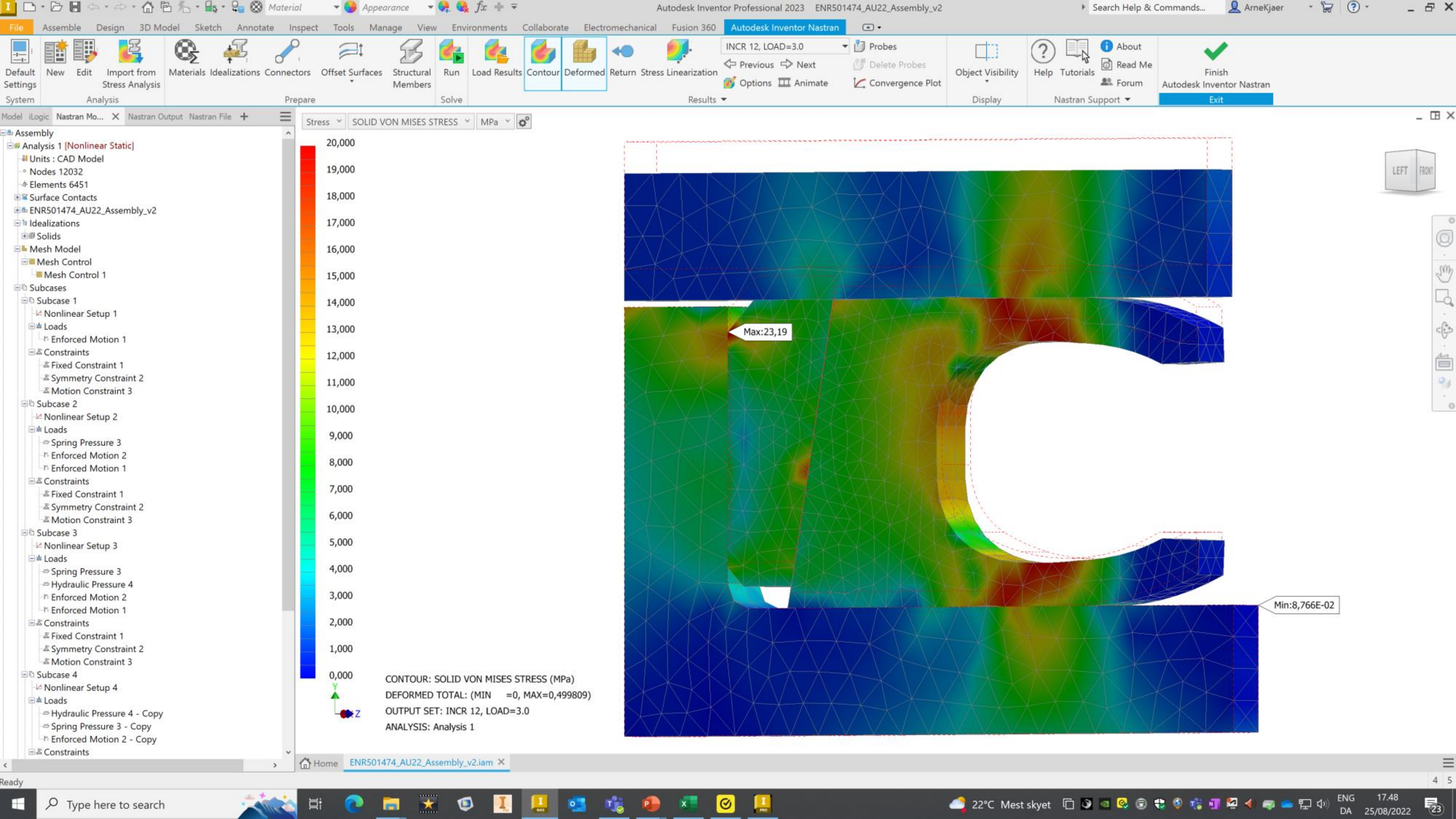
ENG DA 17.48 25/08/2022


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Run
Load Results
Contour
Deformed
Return
Stress Linearization
INCR 12, LOAD=3.0
Previous
Next
Options
Animate
Probes
Delete Probes
Convergence Plot
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
System Analysis Prepare Solve Results Display Nastran Support
Model iLogic Nastran Mo... Nastran Output Nastran File
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 12032
Elements 6451
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
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Home ENR501474_AU22_Assembly_v2.iam
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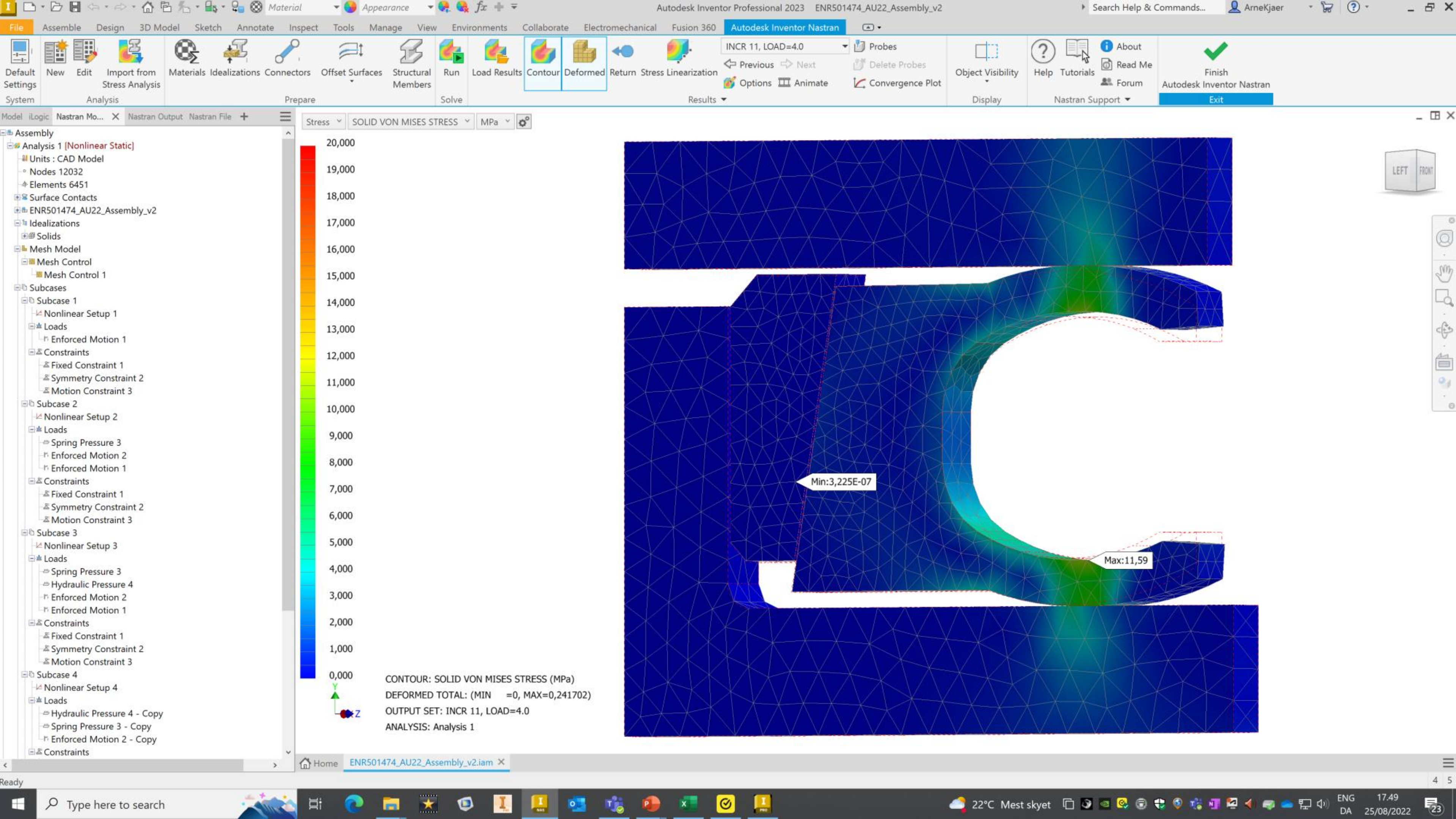
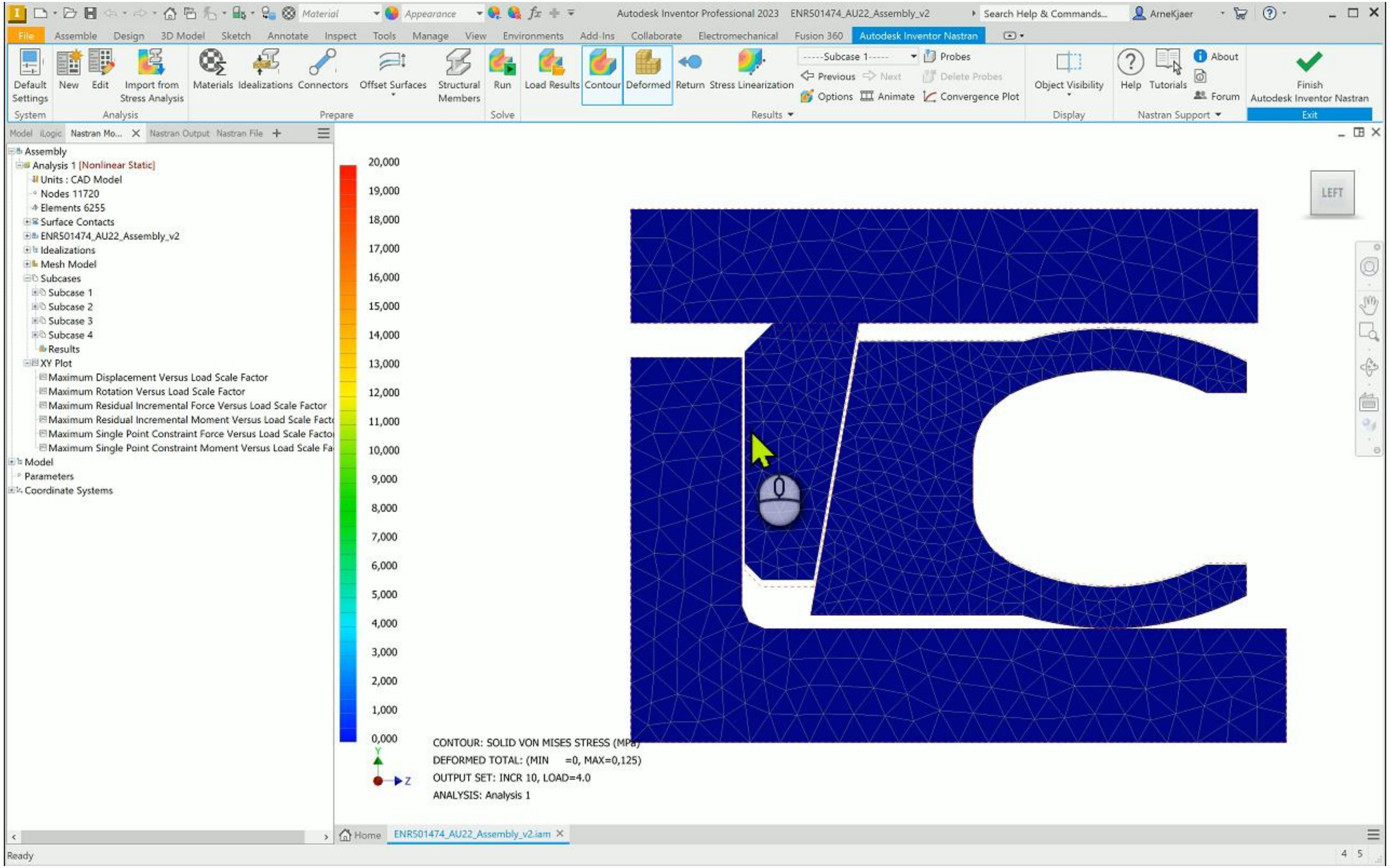
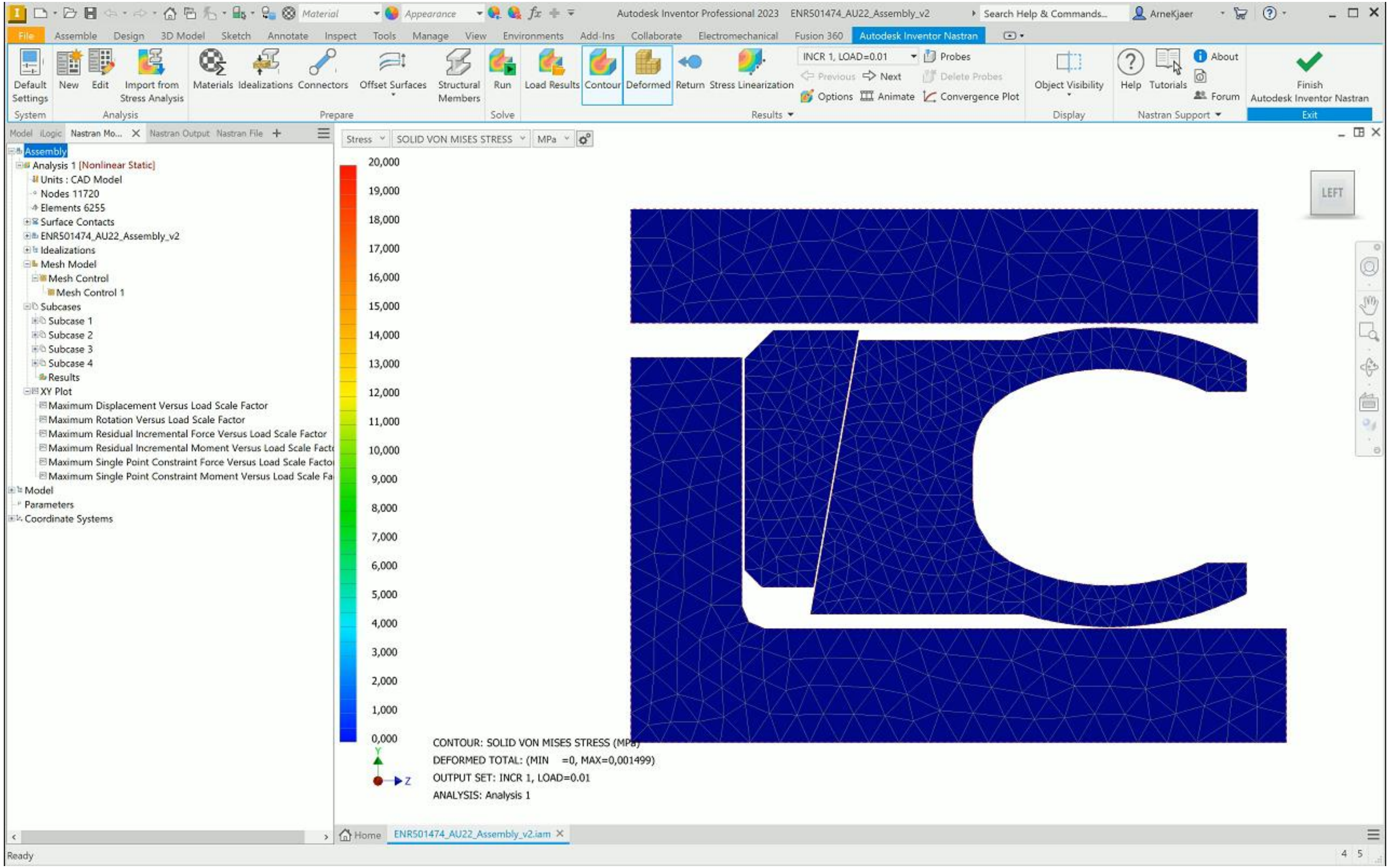
ENG DA
17.48
25/08/2022

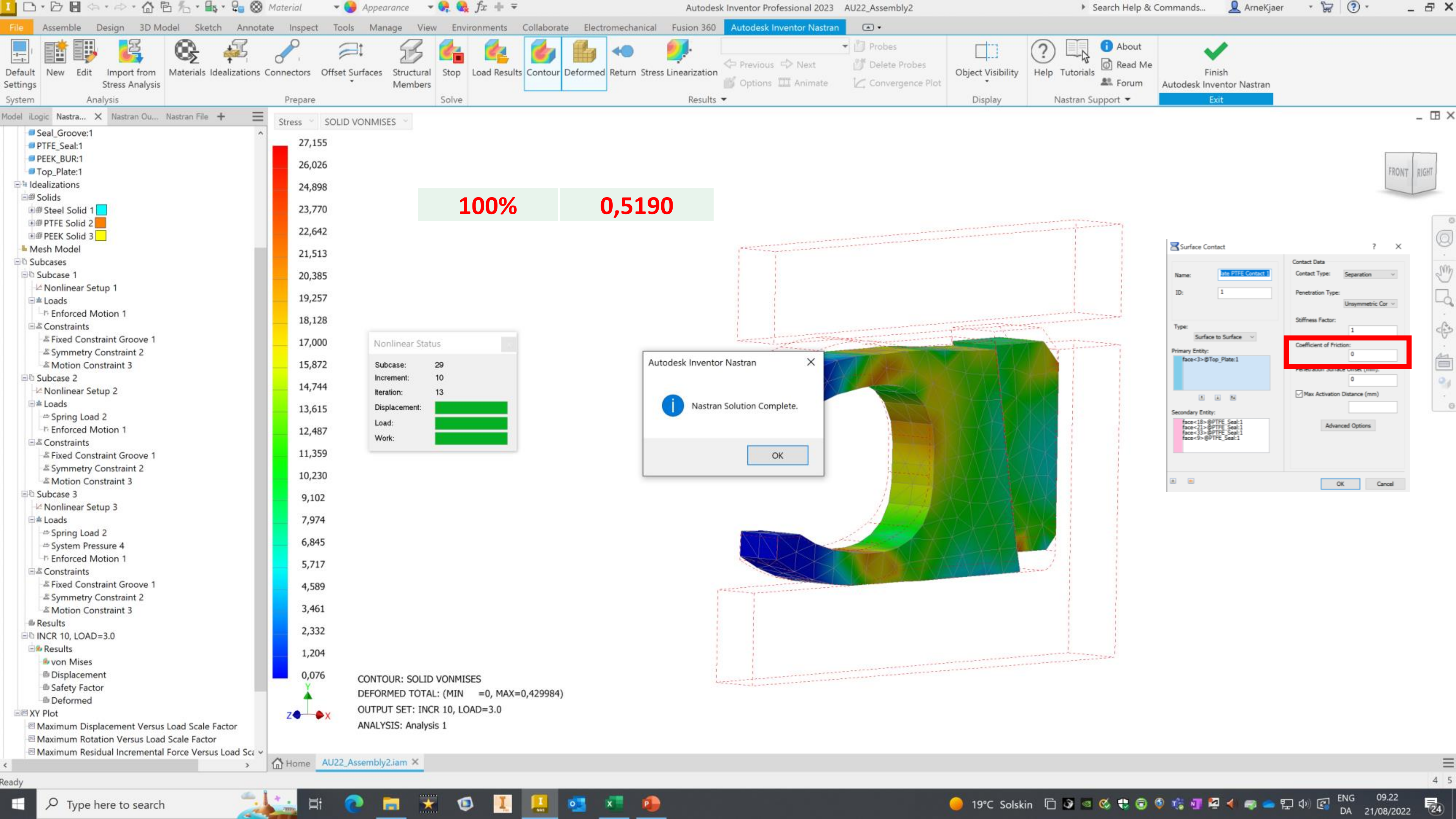

Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Run
Load Results
Contour
Deformed
Return
Stress Linearization
INCR 11, LOAD=4.0
Previous
Next
Options
Animate
Probes
Delete Probes
Convergence Plot
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System Analysis Prepare Solve Results Display Nastran Support Exit
Model iLogic Nastran Mo... Nastran Output Nastran File
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 12032
Elements 6451
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Enforced Motion 2 - Copy
Constraints
Stress SOLID VON MISES STRESS MPa
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0,000
Min:3,225E-07
Max:11,59
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,241702)
OUTPUT SET: INCR 11, LOAD=4.0
ANALYSIS: Analysis 1
Home ENR501474_AU22_Assembly_v2.iam
Ready
Type here to search
22°C Mest skyet
17.49
25/08/2022


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Autodesk Inventor Nastran
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
Subcases
Results
XY Plot
Maximum Displacement Versus Load Scale Factor
Maximum Rotation Versus Load Scale Factor
Maximum Residual Incremental Force Versus Load Scale Factor
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,125)
OUTPUT SET: INCR 10, LOAD=4.0
ANALYSIS: Analysis 1
LEFT

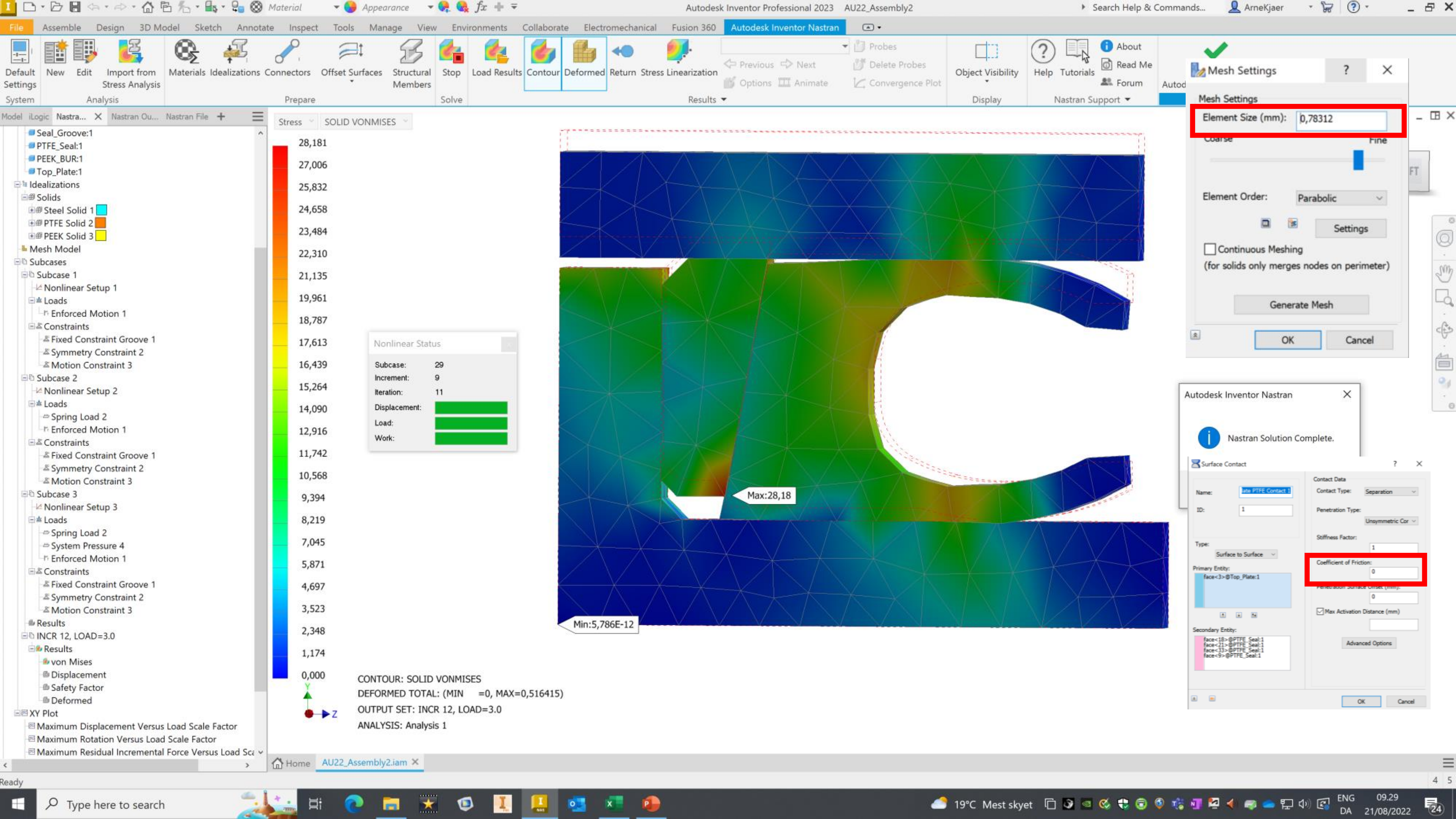


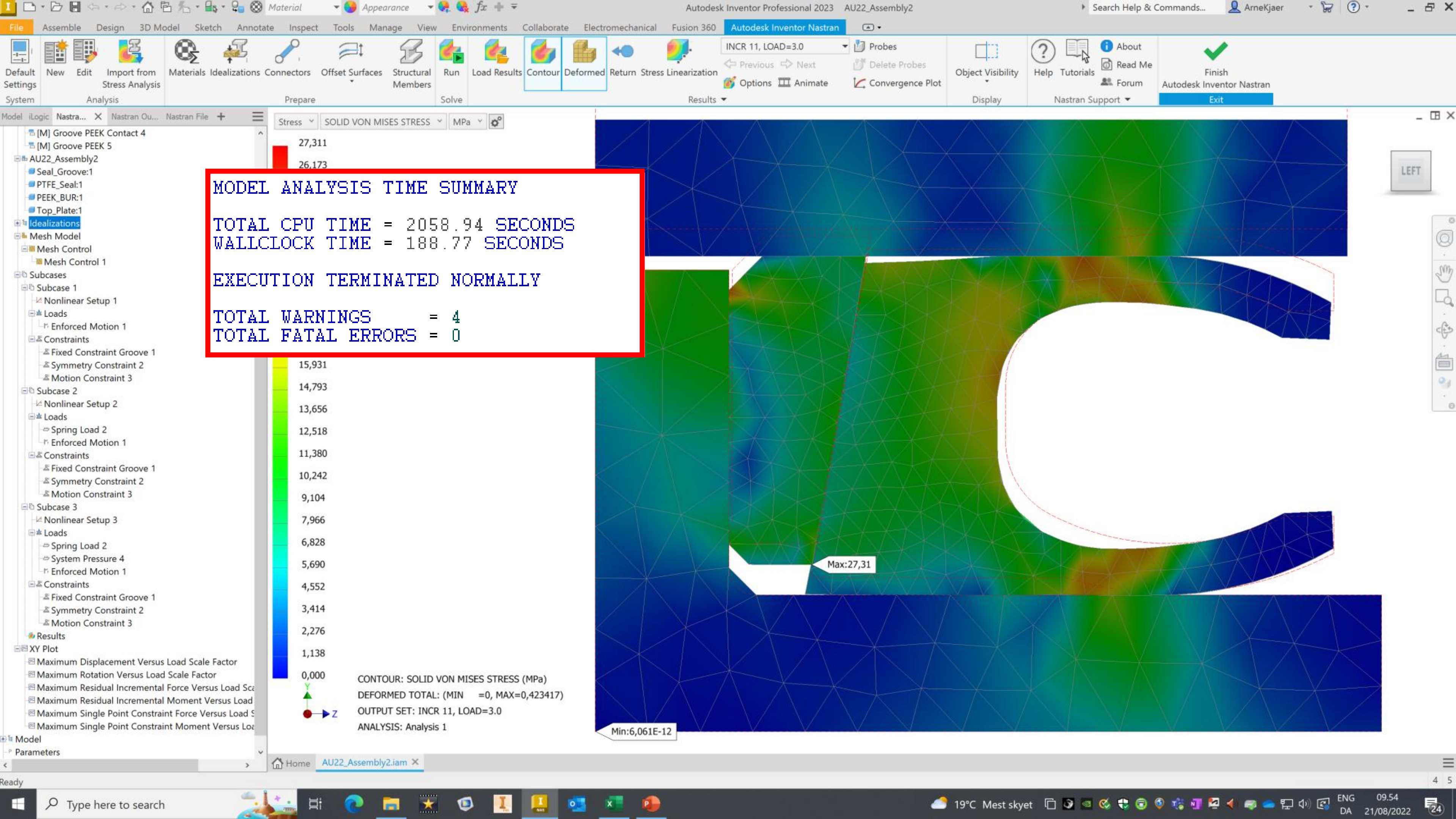
AUTODESK UNIVERSITY

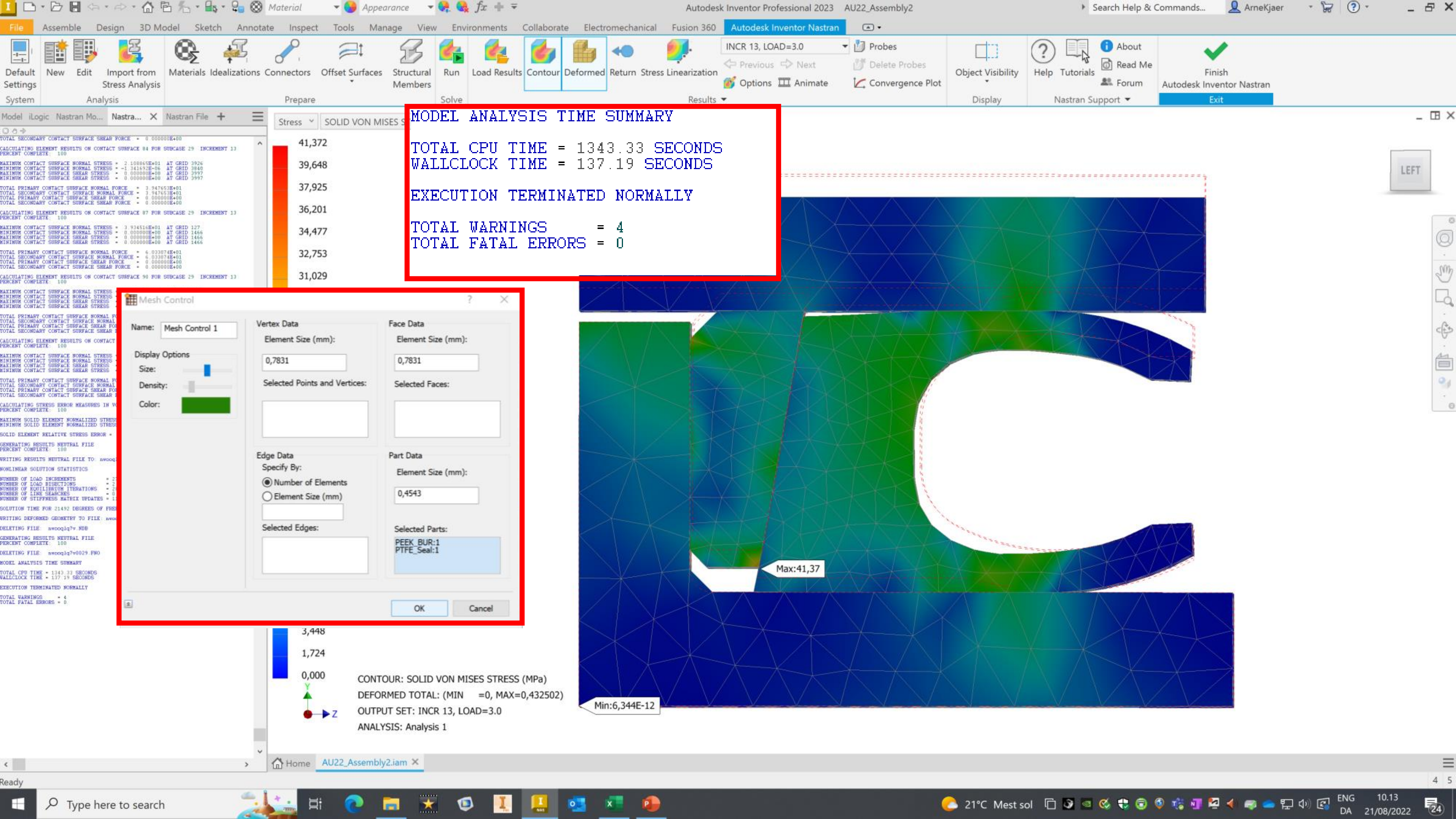
Run the Analysis with Different Mesh



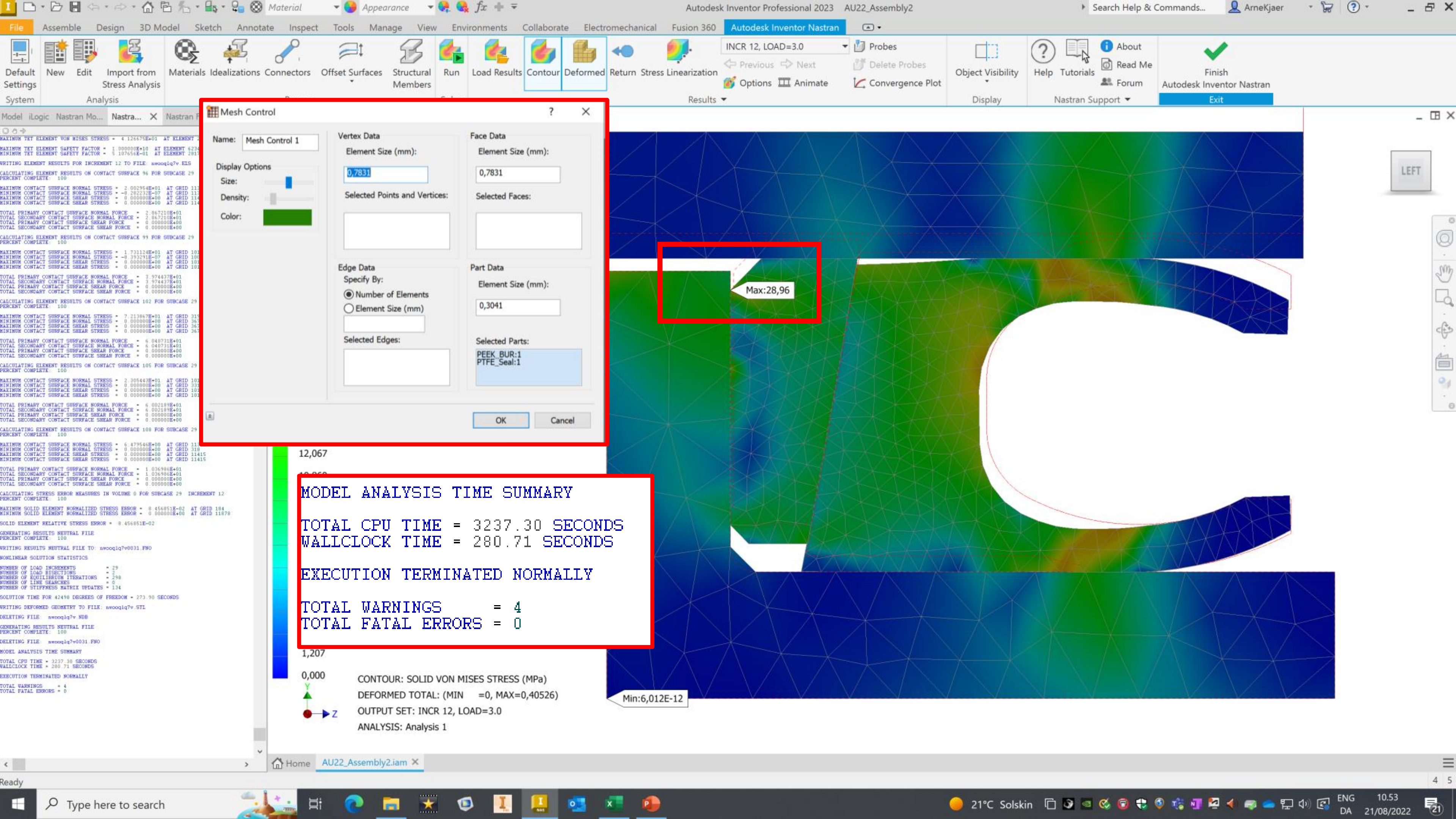
Autodesk Inventor Professional 2023 AU22_Assembly2
Autodesk Inventor Nastran
100%
0,5190
Nonlinear Status
Subcase: 29
Increment: 10
Iteration: 13
Displacement:
Load:
Work:
Autodesk Inventor Nastran
Nastran Solution Complete.
OK
Surface Contact
Coefficient of Friction:
0
CONTOUR: SOLID VONMISES
DEFORMED TOTAL: (MIN =0, MAX=0,429984)
OUTPUT SET: INCR 10, LOAD=3.0
ANALYSIS: Analysis 1

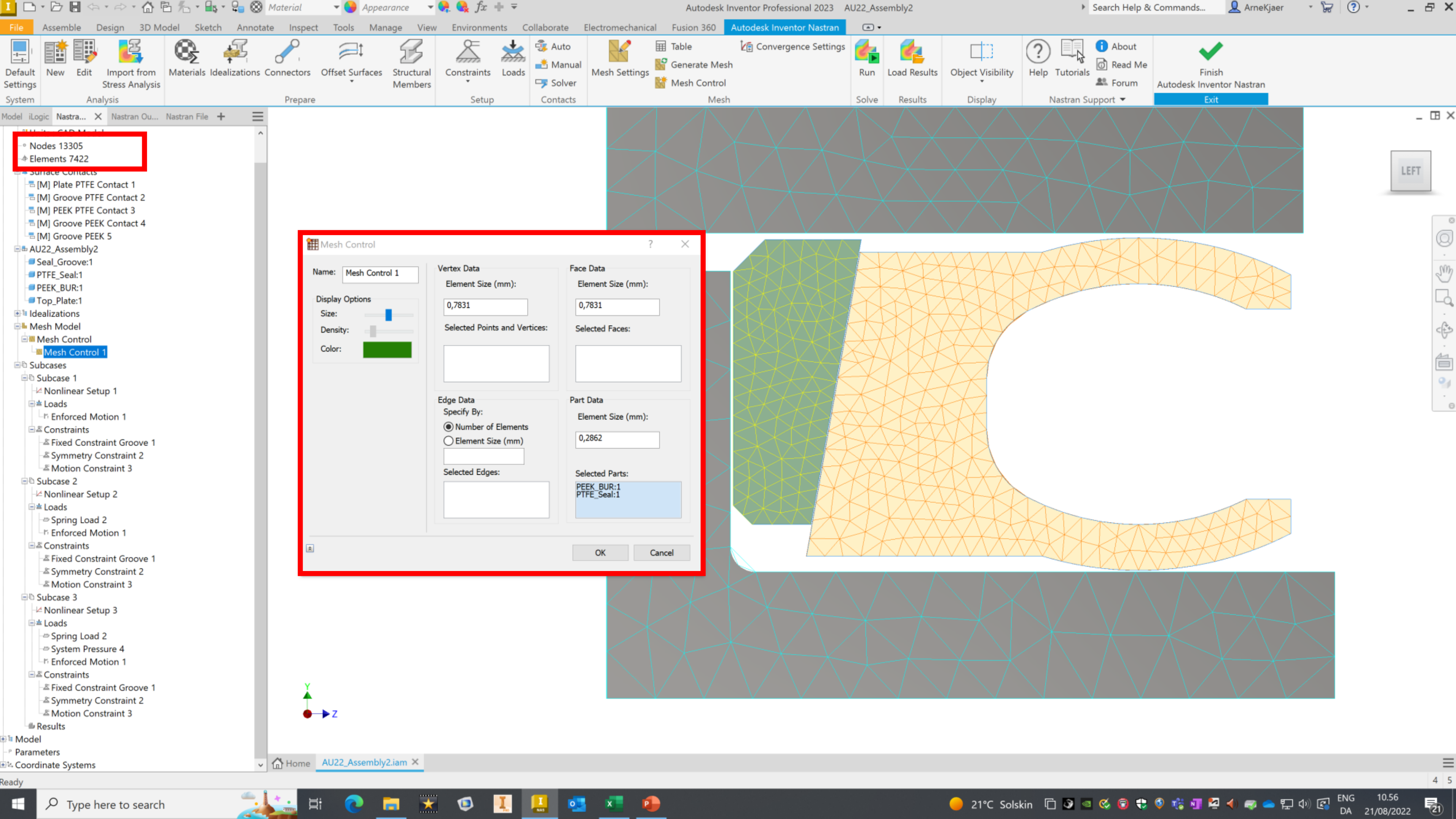
Autodesk Inventor Professional 2023 AU22_Assembly2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings New Edit Import from Stress Analysis Materials Idealizations Connectors Offset Surfaces Structural Members Stop Load Results Contour Deformed Return Stress Linearization
Probes Previous Next Delete Probes Options Animate Convergence Plot Object Visibility Help Tutorials About Read Me Forum
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Solids
Steel Solid 1
PTFE Solid 2
PEEK Solid 3
Mesh Model
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Spring Load 2
Subcase 3
Nonlinear Setup 3
System Pressure 4
Results
INCR 12, LOAD=3.0
von Mises
Displacement
Safety Factor
Deformed
XY Plot
Maximum Displacement Versus Load Scale Factor
Maximum Rotation Versus Load Scale Factor
Maximum Residual Incremental Force Versus Load Sca
Stress SOLID VONMISES
28,181
27,006
25,832
24,658
23,484
22,310
21,135
19,961
18,787
17,613
16,439
15,264
14,090
12,916
11,742
10,568
9,394
8,219
7,045
5,871
4,697
3,523
2,348
1,174
0,000
Nonlinear Status
Subcase: 29
Increment: 9
Iteration: 11
Displacement:
Load:
Work:
Max:28,18
Min:5,786E-12
CONTOUR: SOLID VONMISES
DEFORMED TOTAL: (MIN =0, MAX=0,516415)
OUTPUT SET: INCR 12, LOAD=3.0
ANALYSIS: Analysis 1
Mesh Settings
Element Size (mm): 0,78312
Coarse Fine
Element Order: Parabolic
Settings
Continuous Meshing
(for solids only merges nodes on perimeter)
Generate Mesh
OK Cancel
Autodesk Inventor Nastran
Nastran Solution Complete.
Surface Contact
Name: late PTFE Contact 1
ID: 1
Type: Surface to Surface
Primary Entity: face<3>@Top_Plate:1
Secondary Entity: face<18>@PTFE_Seal:1 face<21>@PTFE_Seal:1 face<33>@PTFE_Seal:1 face<9>@PTFE_Seal:1
Contact Data
Contact Type: Separation
Penetration Type: Unsymmetric Cor
Stiffness Factor: 1
Coefficient of Friction: 0
Max Activation Distance (mm)
Advanced Options
OK Cancel
Home AU22_Assembly2.iam
Ready
Type here to search
19°C Mest skyet
ENG DA 09.29 21/08/2022

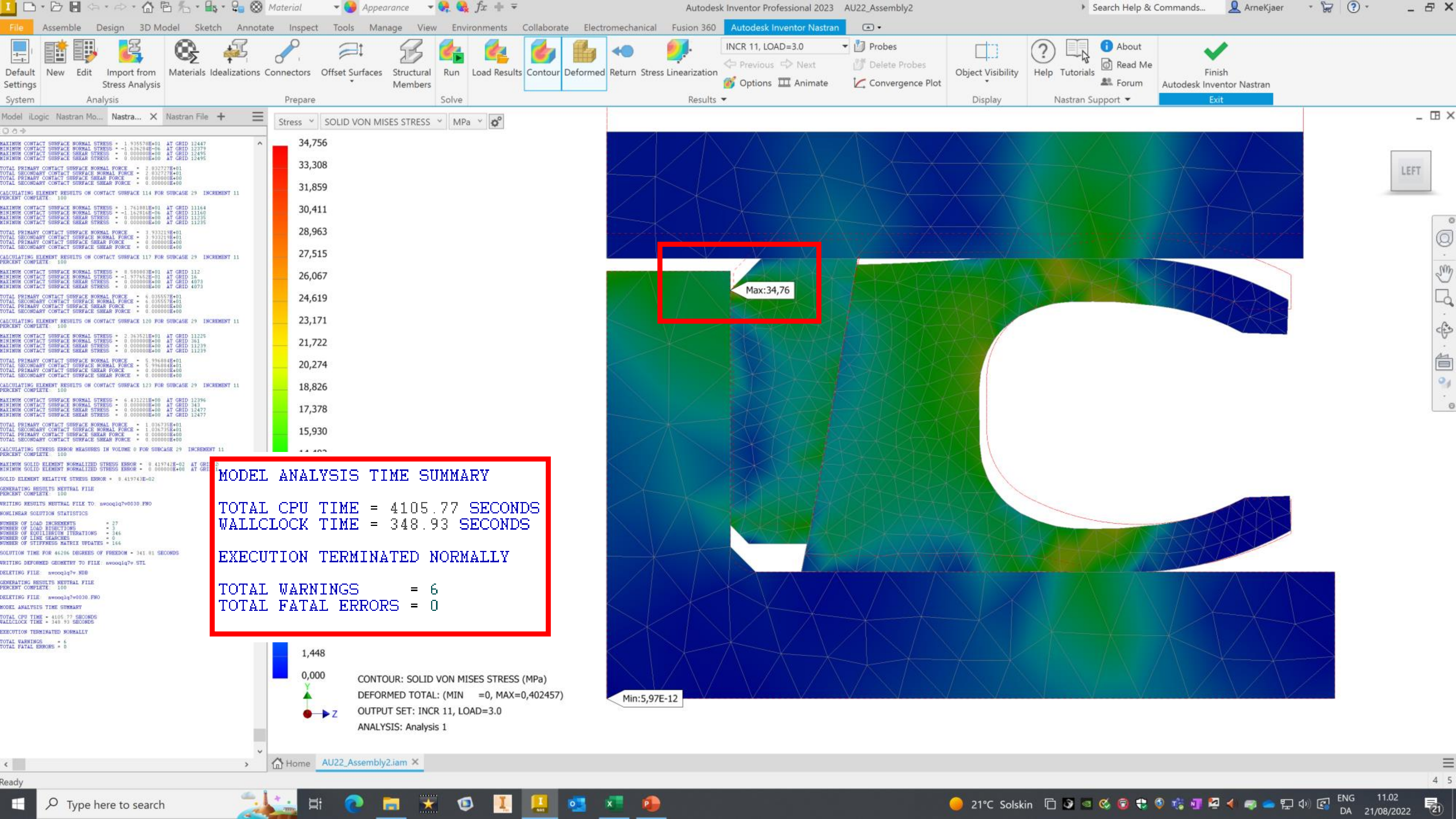

Autodesk Inventor Professional 2023 AU22_Assembly2
Autodesk Inventor Nastran
MODEL ANALYSIS TIME SUMMARY
TOTAL CPU TIME = 2058.94 SECONDS
WALLCLOCK TIME = 188.77 SECONDS
EXECUTION TERMINATED NORMALLY
TOTAL WARNINGS = 4
TOTAL FATAL ERRORS = 0
Stress
SOLID VON MISES STRESS
MPa
27,311
26,173
15,931
14,793
13,656
12,518
11,380
10,242
9,104
7,966
6,828
5,690
4,552
3,414
2,276
1,138
0,000
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,423417)
OUTPUT SET: INCR 11, LOAD=3.0
ANALYSIS: Analysis 1
Max:27,31
Min:6,061E-12
INCR 11, LOAD=3.0
AU22_Assembly2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Spring Load 2
Subcase 3
Nonlinear Setup 3
System Pressure 4
Results
XY Plot
Maximum Displacement Versus Load Scale Factor
Maximum Rotation Versus Load Scale Factor
21/08/2022

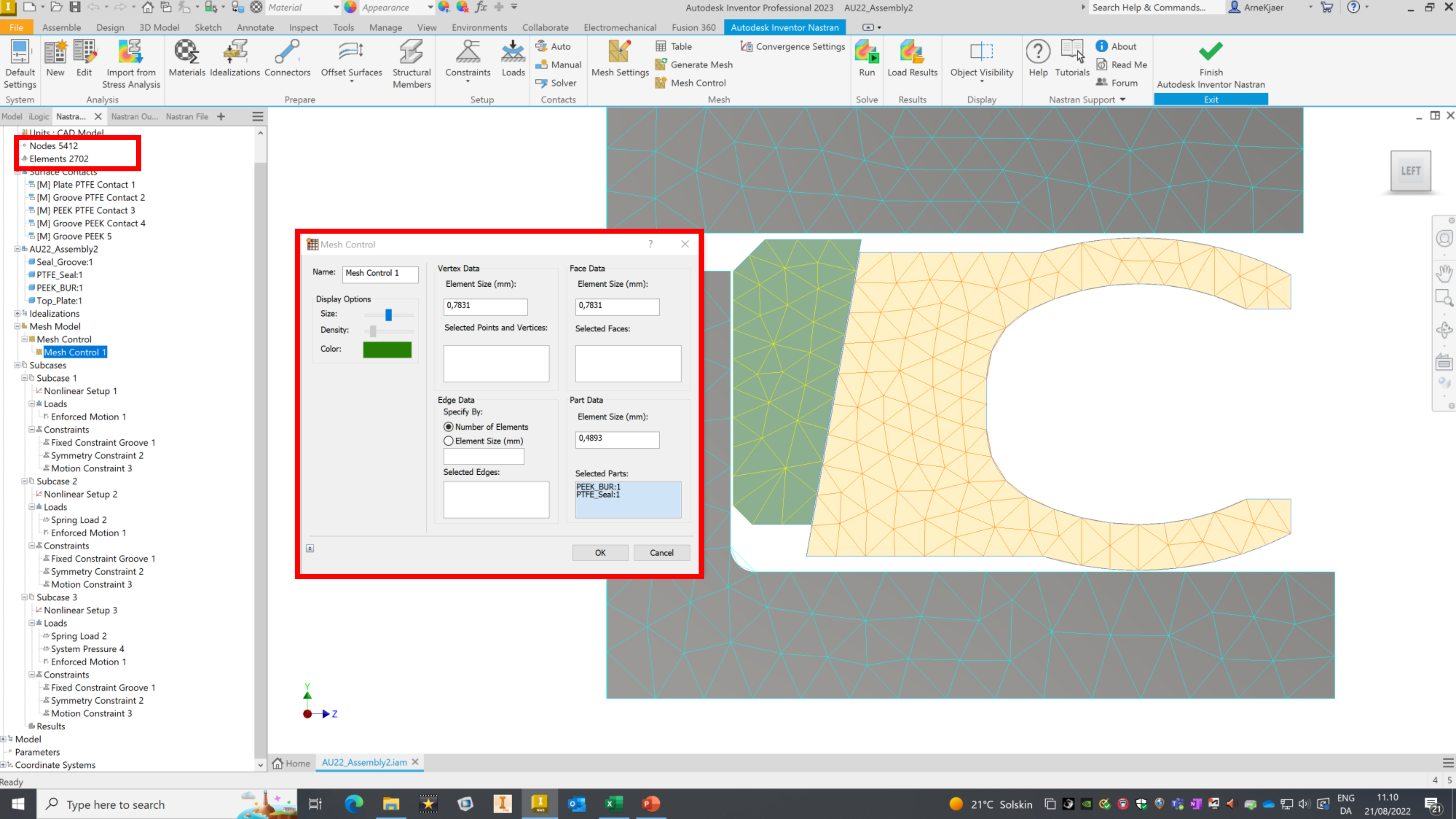


Autodesk Inventor Professional 2023 AU22_Assembly2
Autodesk Inventor Nastran
MODEL ANALYSIS TIME SUMMARY
TOTAL CPU TIME = 1343.33 SECONDS
WALLCLOCK TIME = 137.19 SECONDS
EXECUTION TERMINATED NORMALLY
TOTAL WARNINGS = 4
TOTAL FATAL ERRORS = 0
Mesh Control
Name: Mesh Control 1
Display Options
Size:
Density:
Color:
Vertex Data
Element Size (mm):
0,7831
Selected Points and Vertices:
Face Data
Element Size (mm):
0,7831
Selected Faces:
Edge Data
Specify By:
Number of Elements
Element Size (mm)
Selected Edges:
Part Data
Element Size (mm):
0,4543
Selected Parts:
PEEK_BUR:1
PTFE_Seal:1
OK
Cancel
41,372
39,648
37,925
36,201
34,477
32,753
31,029
3,448
1,724
0,000
Max:41,37
Min:6,344E-12
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,432502)
OUTPUT SET: INCR 13, LOAD=3.0
ANALYSIS: Analysis 1


Autodesk Inventor Professional 2023 AU22_Assembly2
Mesh Control
Name: Mesh Control 1
Display Options
Size:
Density:
Color:
Vertex Data
Element Size (mm):
0,7831
Selected Points and Vertices:
Face Data
Element Size (mm):
0,7831
Selected Faces:
Edge Data
Specify By:
Number of Elements
Element Size (mm)
Selected Edges:
Part Data
Element Size (mm):
0,3041
Selected Parts:
PEEK_BUR:1
PTFE_Seal:1
OK
Cancel
Max:28,96
MODEL ANALYSIS TIME SUMMARY
TOTAL CPU TIME = 3237.30 SECONDS
WALLCLOCK TIME = 280.71 SECONDS
EXECUTION TERMINATED NORMALLY
TOTAL WARNINGS = 4
TOTAL FATAL ERRORS = 0
12,067
1,207
0,000
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,40526)
OUTPUT SET: INCR 12, LOAD=3.0
ANALYSIS: Analysis 1
Min:6,012E-12


Autodesk Inventor Professional 2023 AU22_Assembly2
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
Nodes 13305
Elements 7422
Surface Contacts
[M] Plate PTFE Contact 1
[M] Groove PTFE Contact 2
[M] PEEK PTFE Contact 3
[M] Groove PEEK Contact 4
[M] Groove PEEK 5
AU22_Assembly2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Load 2
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Load 2
System Pressure 4
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Results
Model
Parameters
Coordinate Systems
Mesh Control
Name: Mesh Control 1
Display Options
Size:
Density:
Color:
Vertex Data
Element Size (mm):
0,7831
Selected Points and Vertices:
Face Data
Element Size (mm):
0,7831
Selected Faces:
Edge Data
Specify By:
Number of Elements
Element Size (mm)
Selected Edges:
Part Data
Element Size (mm):
0,2862
Selected Parts:
PEEK_BUR:1
PTFE_Seal:1
OK
Cancel
LEFT
AU22_Assembly2.iam
Ready


Autodesk Inventor Professional 2023 AU22_Assembly2
Autodesk Inventor Nastran
Stress
SOLID VON MISES STRESS
MPa
34,756
33,308
31,859
30,411
28,963
27,515
26,067
24,619
23,171
21,722
20,274
18,826
17,378
15,930
1,448
0,000
Max:34,76
Min:5,97E-12
MODEL ANALYSIS TIME SUMMARY
TOTAL CPU TIME = 4105.77 SECONDS
WALLCLOCK TIME = 348.93 SECONDS
EXECUTION TERMINATED NORMALLY
TOTAL WARNINGS = 6
TOTAL FATAL ERRORS = 0
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,402457)
OUTPUT SET: INCR 11, LOAD=3.0
ANALYSIS: Analysis 1


Autodesk Inventor Professional 2023 AU22_Assembly2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System
Analysis
Prepare
Setup
Contacts
Mesh
Solve
Results
Display
Nastran Support
Exit
Units : CAD Model
Nodes 5412
Elements 2702
Surface Contacts
[M] Plate PTFE Contact 1
[M] Groove PTFE Contact 2
[M] PEEK PTFE Contact 3
[M] Groove PEEK Contact 4
[M] Groove PEEK 5
AU22_Assembly2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Load 2
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Load 2
System Pressure 4
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Results
Model
Parameters
Coordinate Systems
Mesh Control
Name: Mesh Control 1
Display Options
Size:
Density:
Color:
Vertex Data
Element Size (mm):
0,7831
Selected Points and Vertices:
Face Data
Element Size (mm):
0,7831
Selected Faces:
Edge Data
Specify By:
Number of Elements
Element Size (mm)
Selected Edges:
Part Data
Element Size (mm):
0,4893
Selected Parts:
PEEK_BUR:1
PTFE_Seal:1
OK
Cancel
LEFT
Home
AU22_Assembly2.iam
Ready
Type here to search
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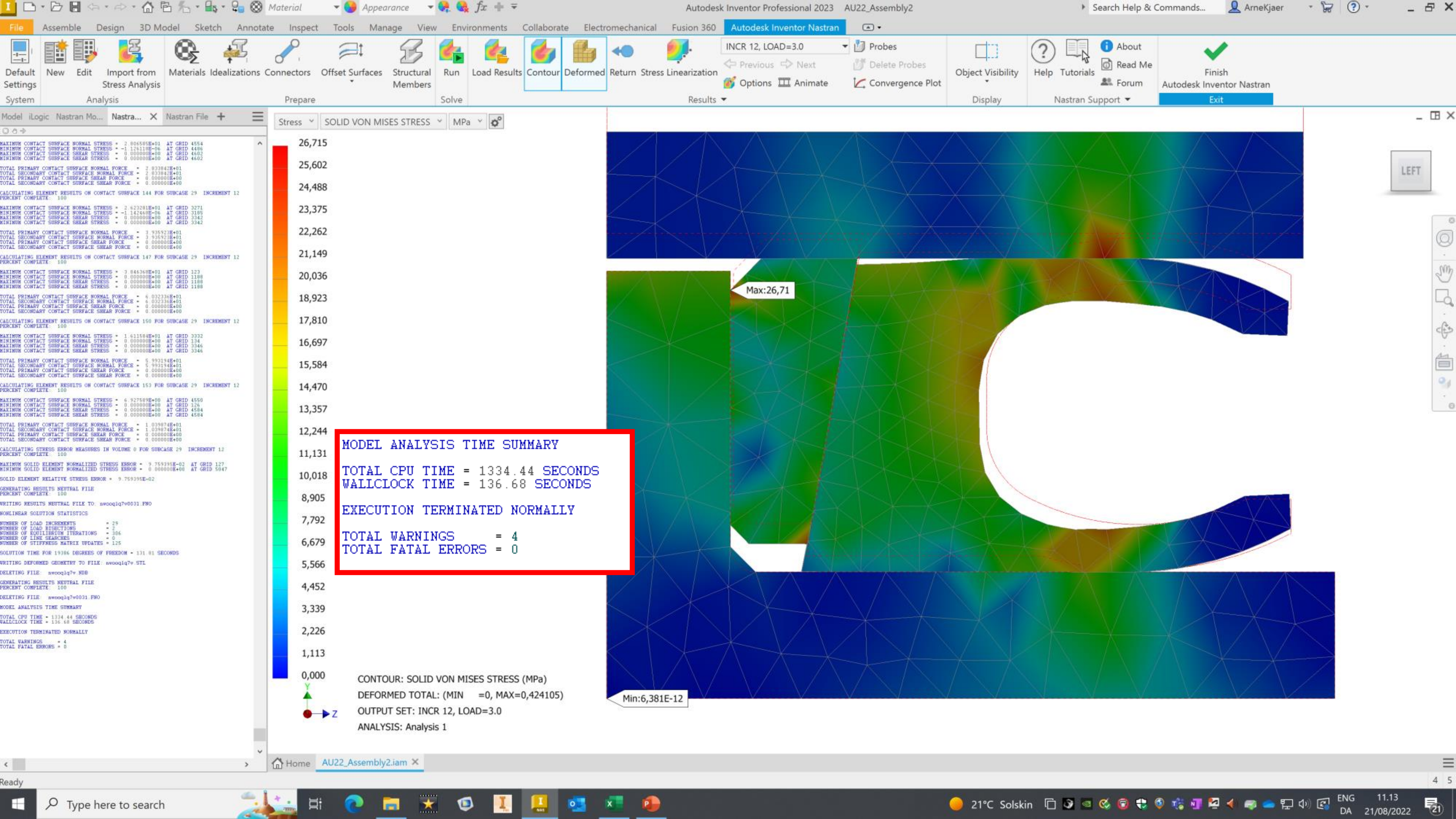
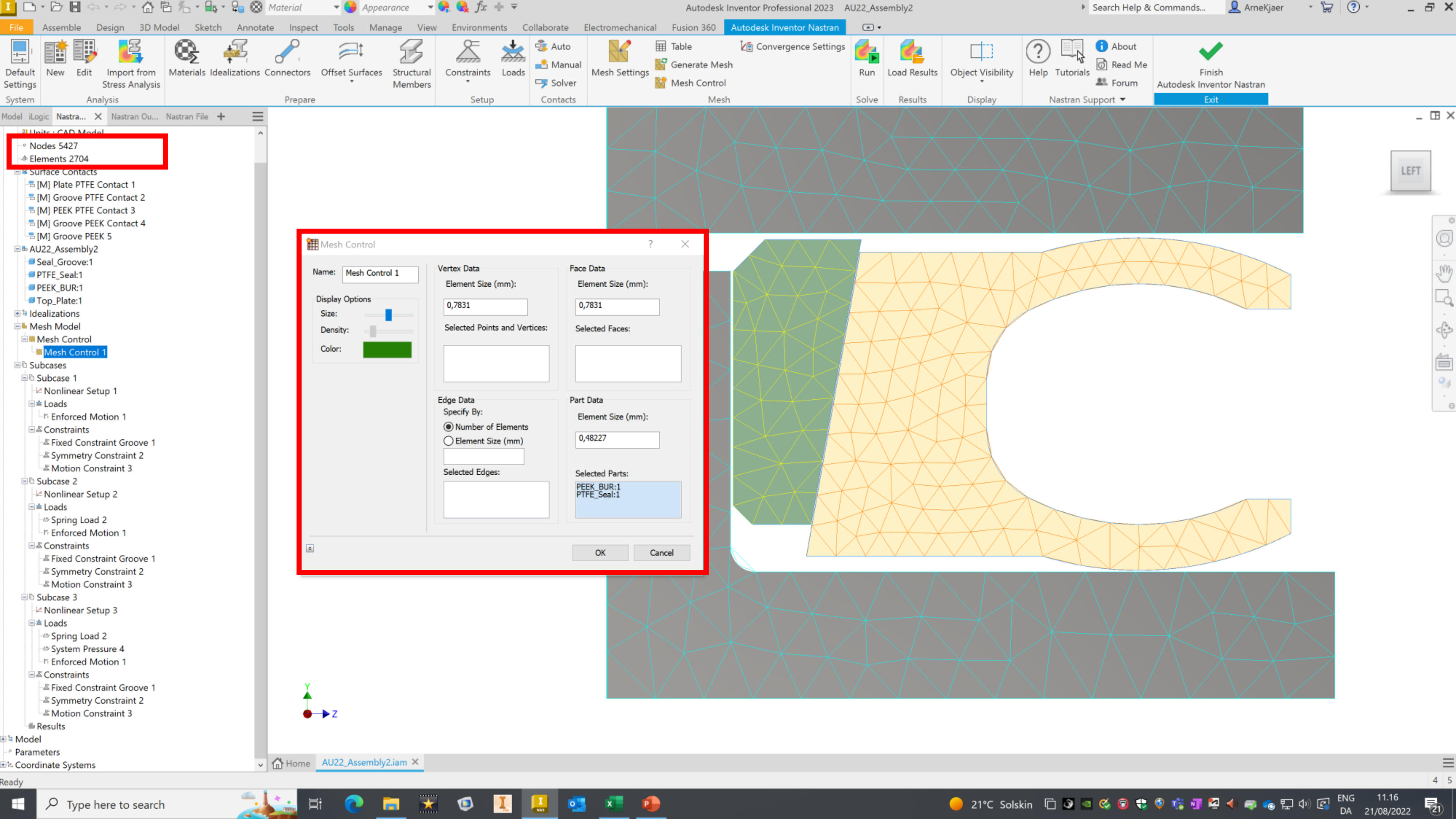
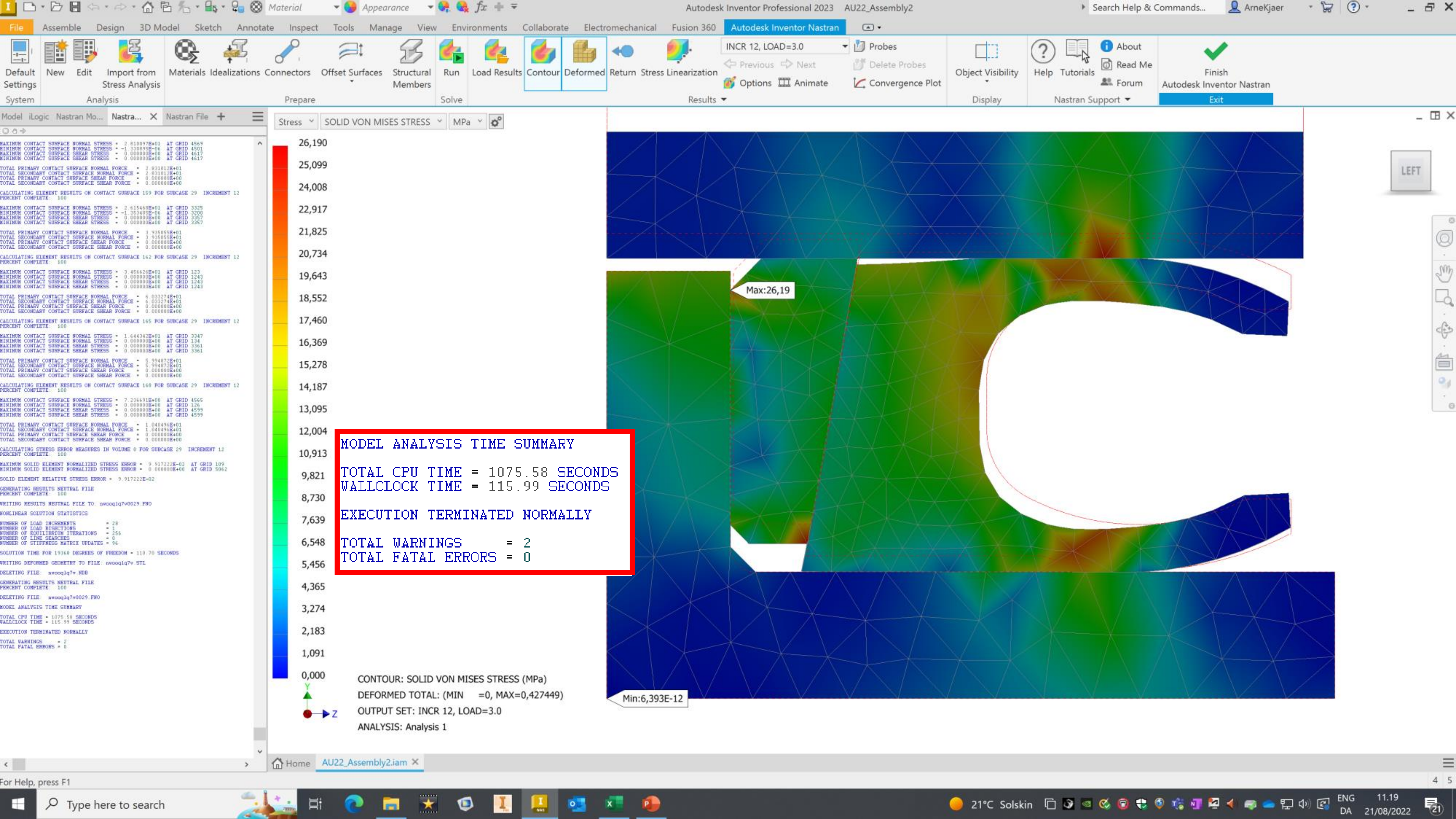
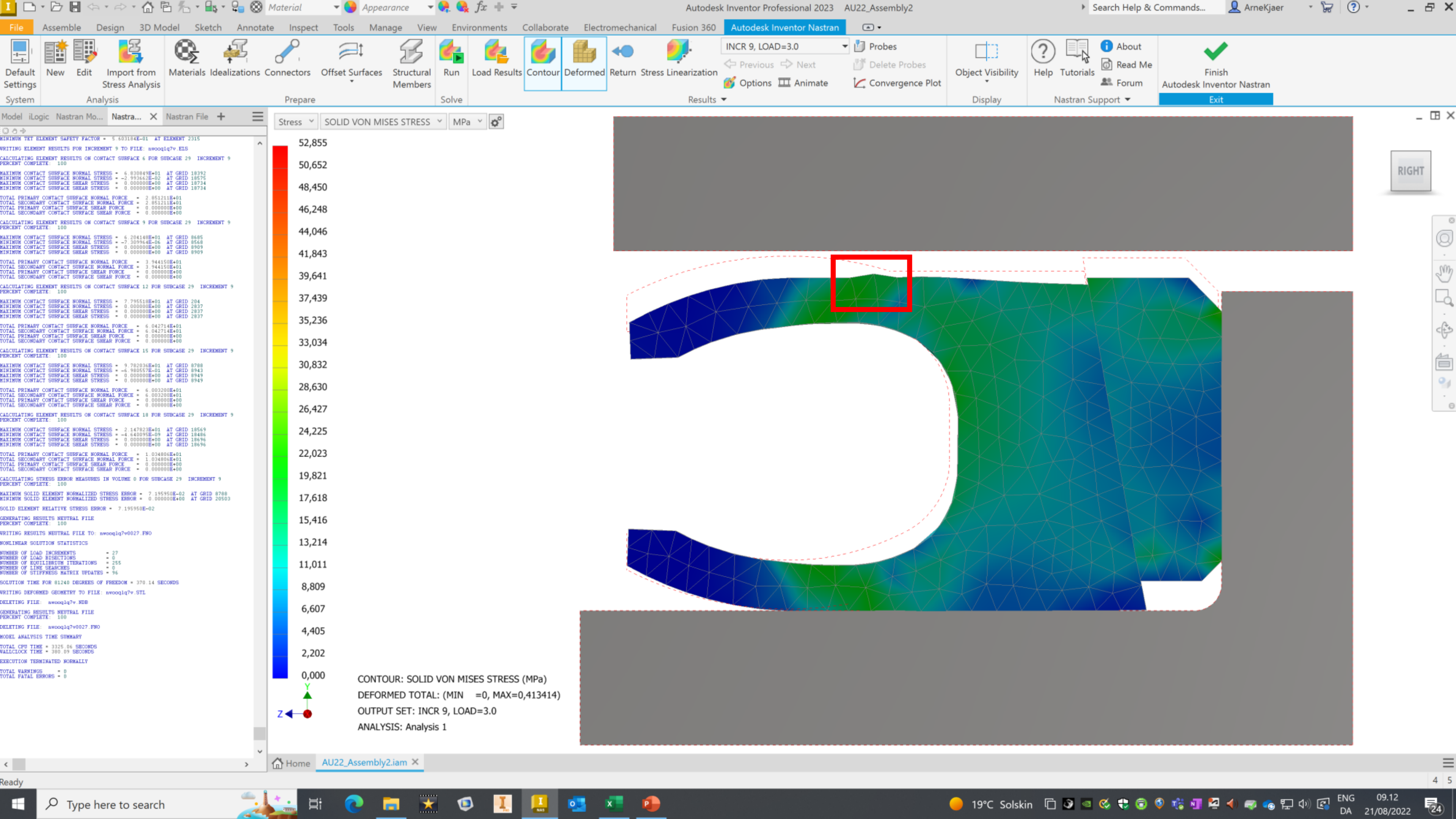
21/08/2022


Autodesk Inventor Professional 2023 AU22_Assembly2
Autodesk Inventor Nastran
Stress
SOLID VON MISES STRESS
MPa
26,715
25,602
24,488
23,375
22,262
21,149
20,036
18,923
17,810
16,697
15,584
14,470
13,357
12,244
11,131
10,018
8,905
7,792
6,679
5,566
4,452
3,339
2,226
1,113
0,000
Max:26,71
Min:6,381E-12
MODEL ANALYSIS TIME SUMMARY
TOTAL CPU TIME = 1334.44 SECONDS
WALLCLOCK TIME = 136.68 SECONDS
EXECUTION TERMINATED NORMALLY
TOTAL WARNINGS = 4
TOTAL FATAL ERRORS = 0
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,424105)
OUTPUT SET: INCR 12, LOAD=3.0
ANALYSIS: Analysis 1

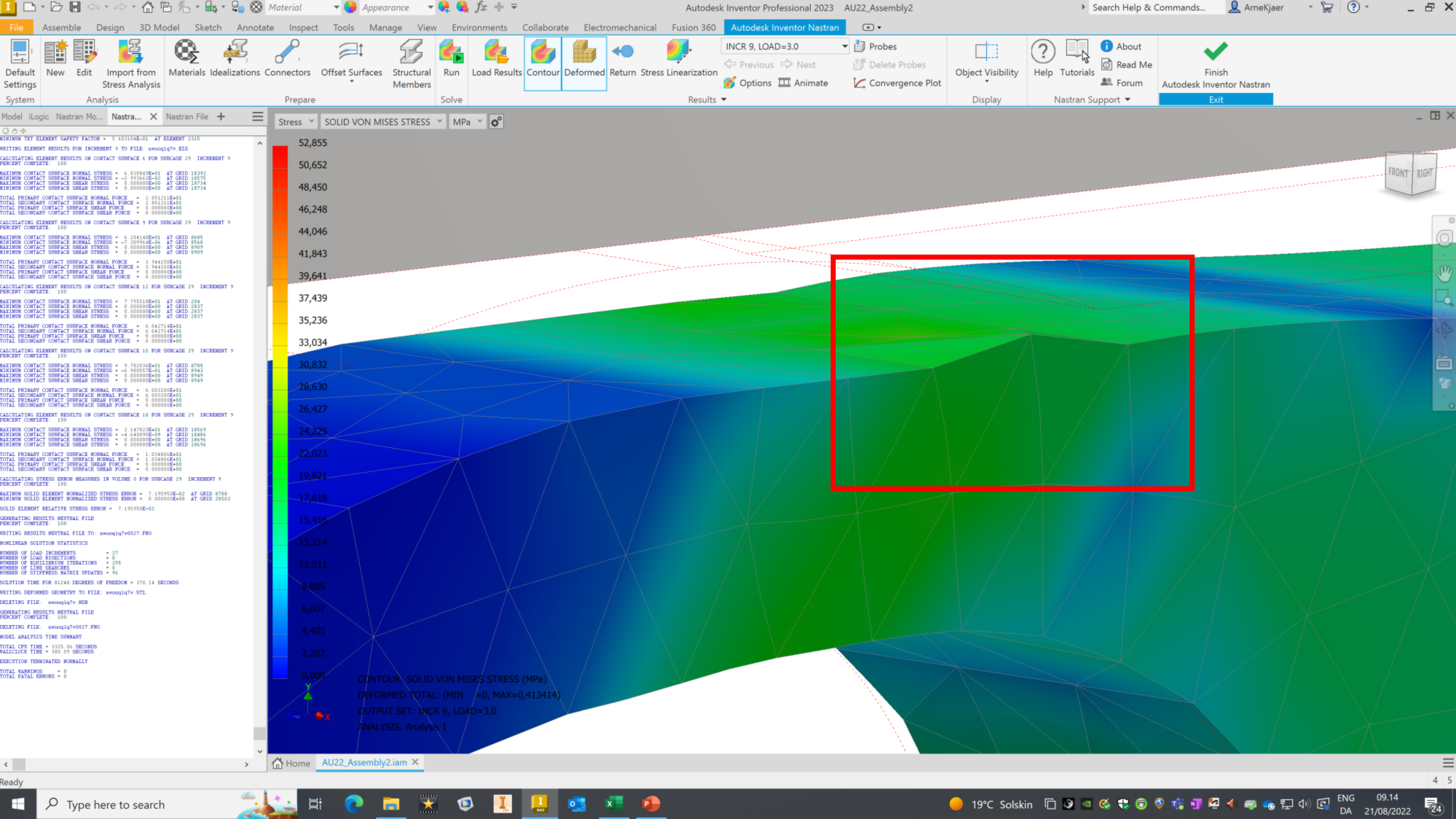


Autodesk Inventor Professional 2023 AU22_Assembly2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Constraints
Loads
Auto
Manual
Solver
Mesh Settings
Table
Generate Mesh
Mesh Control
Convergence Settings
Run
Load Results
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
System Analysis Prepare Setup Contacts Mesh Solve Results Display Nastran Support Exit
Nodes 5427
Elements 2704
Surface Contacts
[M] Plate PTFE Contact 1
[M] Groove PTFE Contact 2
[M] PEEK PTFE Contact 3
[M] Groove PEEK Contact 4
[M] Groove PEEK 5
AU22_Assembly2
Seal_Groove:1
PTFE_Seal:1
PEEK_BUR:1
Top_Plate:1
Idealizations
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Load 2
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Load 2
System Pressure 4
Enforced Motion 1
Constraints
Fixed Constraint Groove 1
Symmetry Constraint 2
Motion Constraint 3
Results
Model
Parameters
Coordinate Systems
Mesh Control
Name: Mesh Control 1
Display Options
Size:
Density:
Color:
Vertex Data
Element Size (mm):
0,7831
Selected Points and Vertices:
Face Data
Element Size (mm):
0,7831
Selected Faces:
Edge Data
Specify By:
Number of Elements
Element Size (mm)
Selected Edges:
Part Data
Element Size (mm):
0,48227
Selected Parts:
PEEK_BUR:1
PTFE_Seal:1
OK
Cancel
LEFT
Home AU22_Assembly2.iam
Ready
Type here to search
21°C Solskin
ENG DA
11.16
21/08/2022


Autodesk Inventor Professional 2023 AU22_Assembly2
Autodesk Inventor Nastran
INCR 12, LOAD=3.0
Stress
SOLID VON MISES STRESS
MPa
26,190
25,099
24,008
22,917
21,825
20,734
19,643
18,552
17,460
16,369
15,278
14,187
13,095
12,004
10,913
9,821
8,730
7,639
6,548
5,456
4,365
3,274
2,183
1,091
0,000
Max:26,19
Min:6,393E-12
MODEL ANALYSIS TIME SUMMARY
TOTAL CPU TIME = 1075.58 SECONDS
WALLCLOCK TIME = 115.99 SECONDS
EXECUTION TERMINATED NORMALLY
TOTAL WARNINGS = 2
TOTAL FATAL ERRORS = 0
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,427449)
OUTPUT SET: INCR 12, LOAD=3.0
ANALYSIS: Analysis 1
AU22_Assembly2.iam



Autodesk Inventor Professional 2023 AU22_Assembly2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Run
Load Results
Contour
Deformed
Return
Stress Linearization
INCR 9, LOAD=3.0
Previous
Next
Options
Animate
Probes
Delete Probes
Convergence Plot
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
System
Analysis
Prepare
Solve
Results
Display
Nastran Support
Stress
SOLID VON MISES STRESS
MPa
52,855
50,652
48,450
46,248
44,046
41,843
39,641
37,439
35,236
33,034
30,832
28,630
26,427
24,225
22,023
19,821
17,618
15,416
13,214
11,011
8,809
6,607
4,405
2,202
0,000
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,413414)
OUTPUT SET: INCR 9, LOAD=3.0
ANALYSIS: Analysis 1
RIGHT
Home
AU22_Assembly2.iam
Ready
Type here to search
19°C Solskin
09.12
21/08/2022



Autodesk Inventor Professional 2023 AU22_Assembly2
File
Assemble
Design
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Electromechanical
Fusion 360
Autodesk Inventor Nastran
Default Settings
New
Edit
Import from Stress Analysis
Materials
Idealizations
Connectors
Offset Surfaces
Structural Members
Run
Load Results
Contour
Deformed
Return
Stress Linearization
INCR 9, LOAD=3.0
Probes
Previous
Next
Delete Probes
Options
Animate
Convergence Plot
Object Visibility
Help
Tutorials
About
Read Me
Forum
Finish Autodesk Inventor Nastran
Exit
System
Analysis
Prepare
Solve
Results
Display
Nastran Support
Stress
SOLID VON MISES STRESS
MPa
52,855
50,652
48,450
46,248
44,046
41,843
39,641
37,439
35,236
33,034
30,832
28,630
26,427
24,225
22,023
19,821
17,618
15,416
13,214
11,011
8,809
6,607
4,405
2,202
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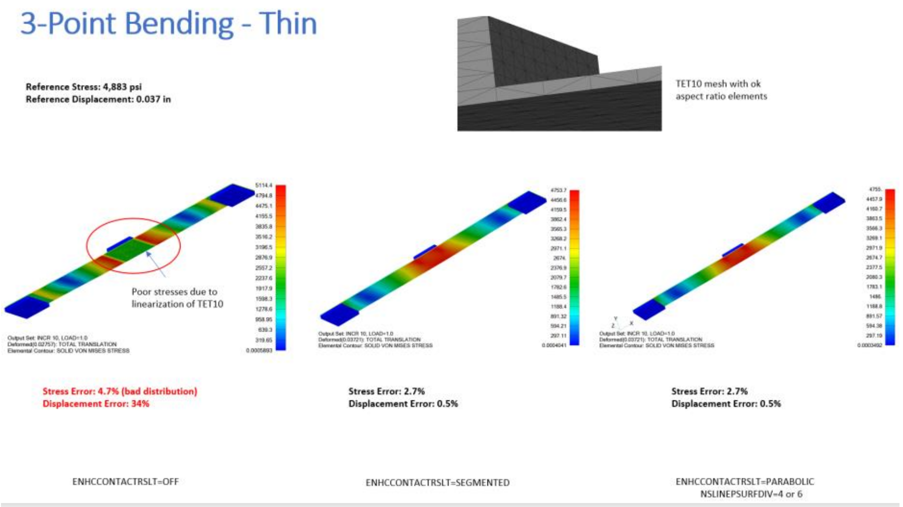
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,413414)
OUTPUT SET: INCR 9, LOAD=3.0
ANALYSIS: Analysis 1
FRONT
RIGHT
Home
AU22_Assembly2.iam
Ready
Type here to search
19°C Solskin
ENG
DA
09.14
21/08/2022

Mesh Aspect Ratio

- Data on the thin beam w/ contact experiments (with ENHCCONTACTRSLT=OFF):
  - Tet Aspect Ratio 8:1 - 77% disp error
  - Tet Aspect Ratio 3:1 - 34% disp error
  - Tet Aspect Ratio 1:1 - 1.9% disp error
- If that aspect ratio is close to 1:1 you should get good displacement results and not need multiple elements through the thickness
- For a 6:1 AR version with 3 layers:
  - Tet Aspect Ration 6:1 (3 layers) - 10.4% disp error
- Getting good aspect ratio is key for ENHCCONTACTRSLT=OFF models



Mesh Aspect Ratio

ENHCCONTACTRSLT

Description	Type	Default
Enhances the contact element formulation for parabolic tet elements. When activated, it will subdivide parabolic tet element primary surfaces into 4 separate sub-surfaces and avoid linearizing the element face. If the model does not have contact on parabolic tet elements, this parameter will have no effect on the solution.	ON/OFF AUTO	AUTO

Parent topic: Results Processor Parameters

Mesh Aspect Ratio

Model with bonded contact between thin parts behaving too stiff in simulation

SHARE

2018-09-05 | Technical Support

Issue:

A model composed of thin parts does not bend properly, such as multiple layers through the thickness of a printed circuit board (PCB). The displacement is too small. This issues applied to products that are using Nastran solver i.e. Autodesk Nastran, Inventor Nastran, Nastran In-CAD and Fusion 360 Simulation.

Causes:

The bonded contact is acting too stiff.

Solution:

Option 1: (Applies to Inventor Nastran, Nastran In-CAD, Nastran)
If the model is composed of parabolic solid elements (tet elements), change the Parameter ENHCCONTACTRSLT to ON. This causes the contact to follow the parabolic elements more accurately. (In Nastran In-CAD, edit the Parameters branch in the browser and find ENHCCONTACTRSLT.)
After changing ENHCCONTACTRSLT, It may also be necessary to adjust the Stiffness Factor to a smaller value in order to obtain a more accurate solution.

Option 2: (Applies to Inventor Nastran, Nastran In-CAD, Nastran, Fusion 360 Simulation)
If the model is composed of parabolic solid elements (tet elements), use offset bonded contact with activation distance specified.

Products:

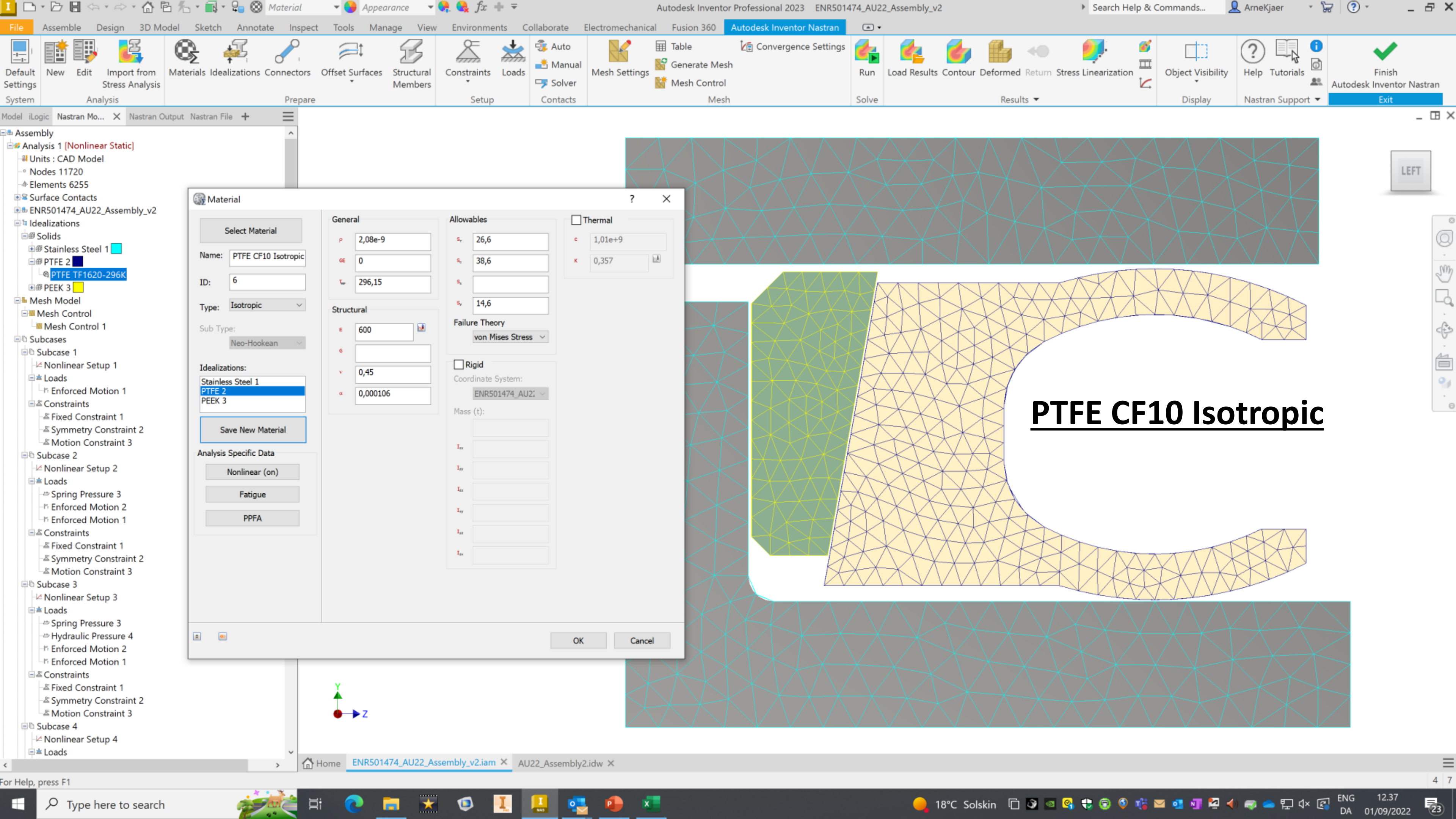
Fusion 360; Nastran; Inventor Nastran;

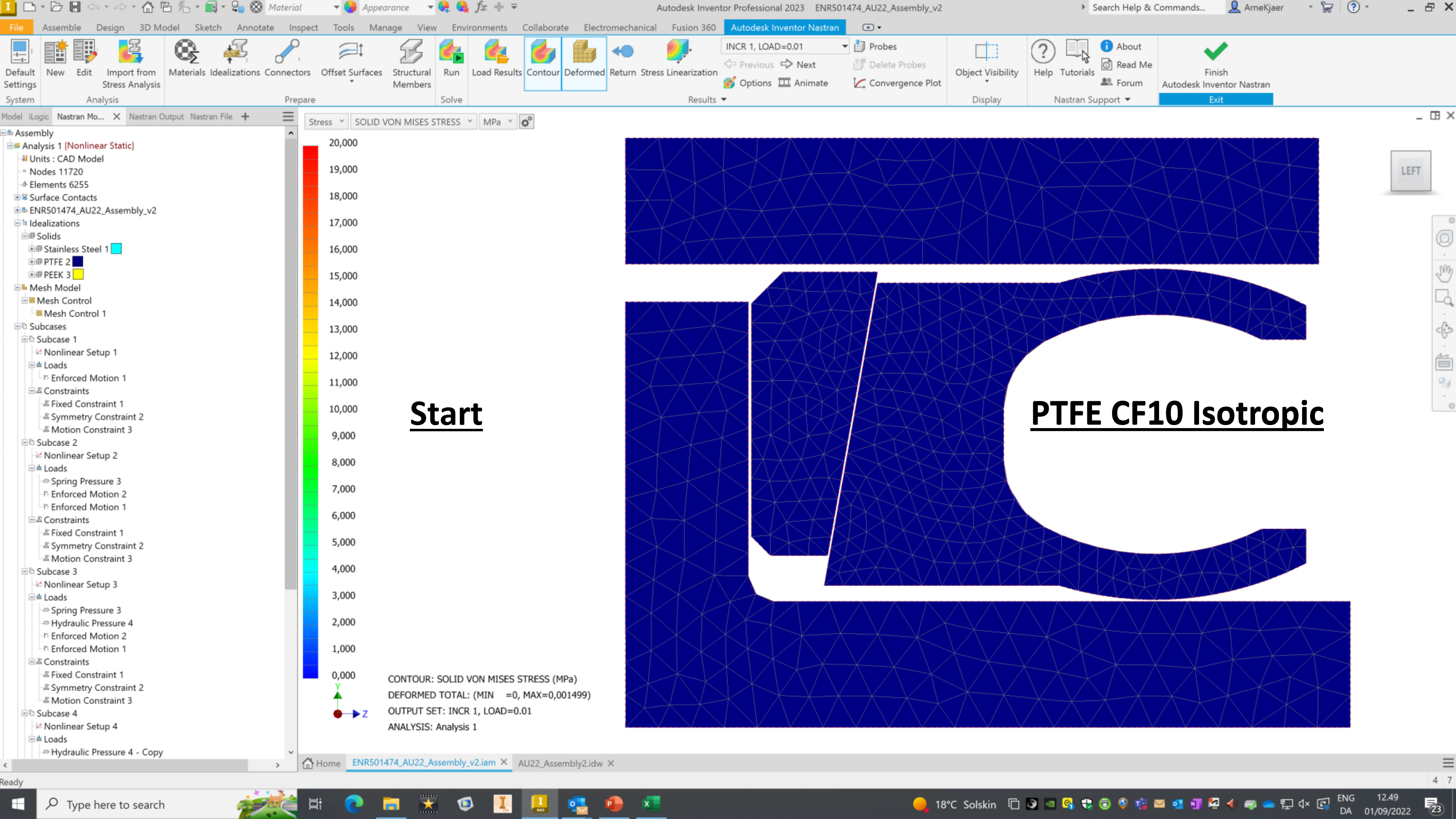
Versions:

all;

AUTODESK UNIVERSITY

Final Run 1 and Run 2


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
File Assemble Design 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Electromechanical Fusion 360 Autodesk Inventor Nastran
Default Settings New Edit Import from Stress Analysis Materials Idealizations Connectors Offset Surfaces Structural Members Constraints Loads Auto Manual Solver Mesh Settings Table Generate Mesh Mesh Control Convergence Settings Run Load Results Contour Deformed Return Stress Linearization Object Visibility Help Tutorials Finish Autodesk Inventor Nastran
System Analysis Prepare Setup Contacts Mesh Solve Results Display Nastran Support Exit
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PTFE TF1620-296K
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Material
Select Material
Name: PTFE CF10 Isotropic
ID: 6
Type: Isotropic
Sub Type: Neo-Hookean
Idealizations:
Stainless Steel 1
PTFE 2
PEEK 3
Save New Material
Analysis Specific Data
Nonlinear (on)
Fatigue
PPFA
General
2,08e-9
0
296,15
Structural
600
0,45
0,000106
Allowables
26,6
38,6
14,6
Failure Theory
von Mises Stress
Rigid
Coordinate System:
Mass (t):
Thermal
1,01e+9
0,357
OK
Cancel
PTFE CF10 Isotropic
LEFT
Home ENR501474_AU22_Assembly_v2.iam AU22_Assembly2.idw
For Help, press F1
Type here to search
18°C Solskin
ENG DA 12.37 01/09/2022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PTFE CF10 Isotropic
Stress
SOLID VON MISES STRESS
MPa
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Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
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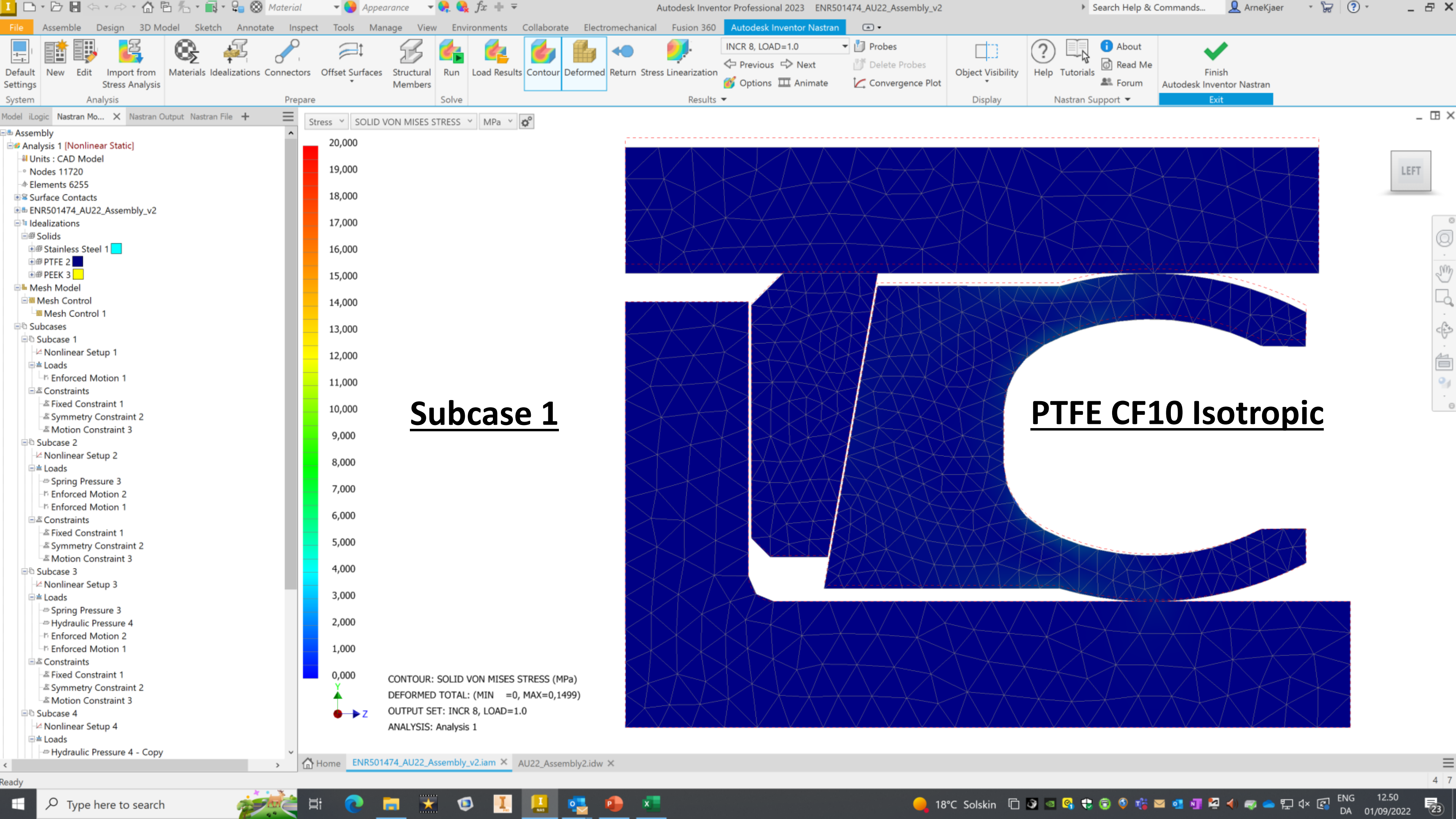
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy



Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Autodesk Inventor Nastran
Stress
SOLID VON MISES STRESS
MPa
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
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Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
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Hydraulic Pressure 4 - Copy
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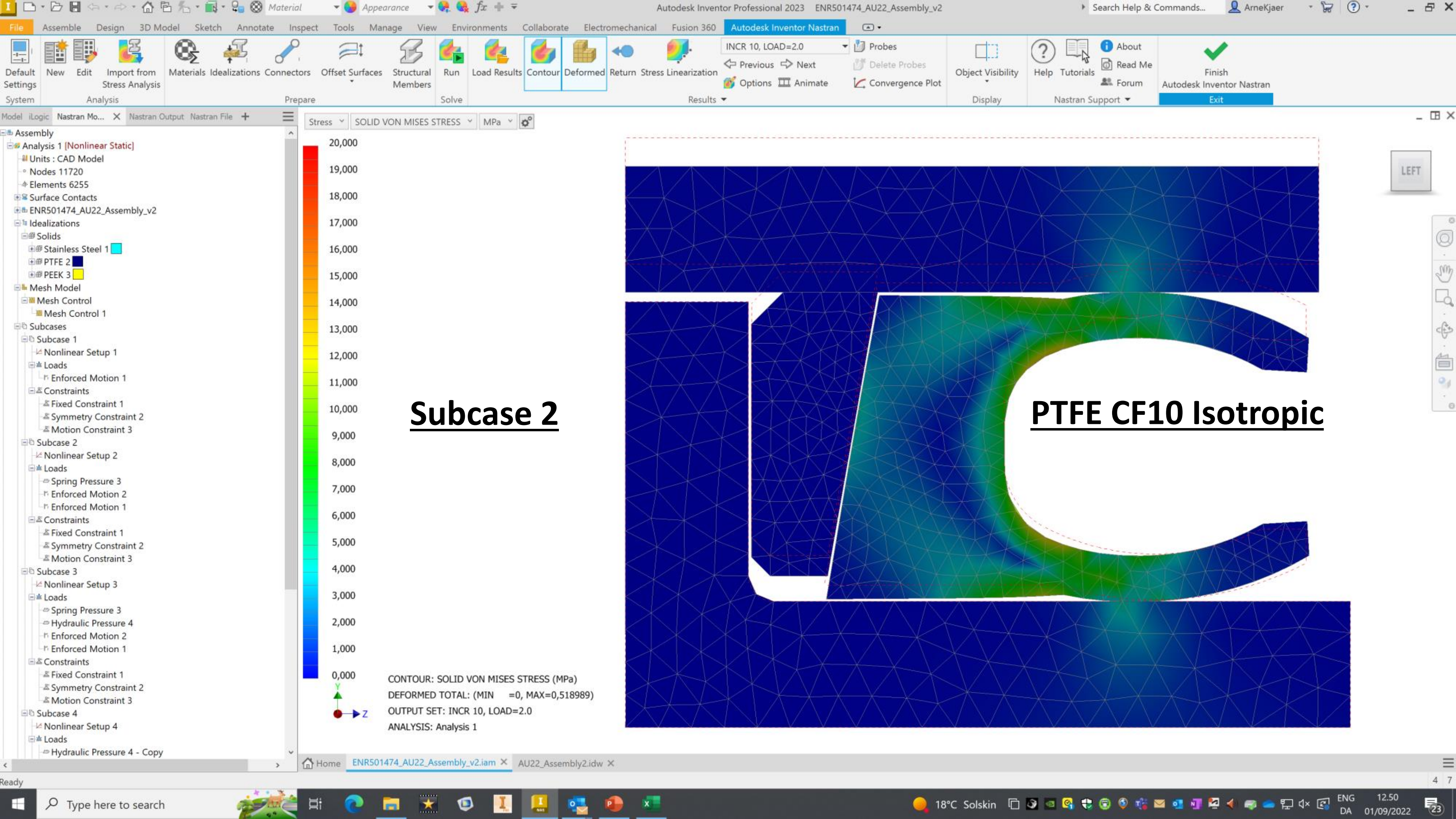
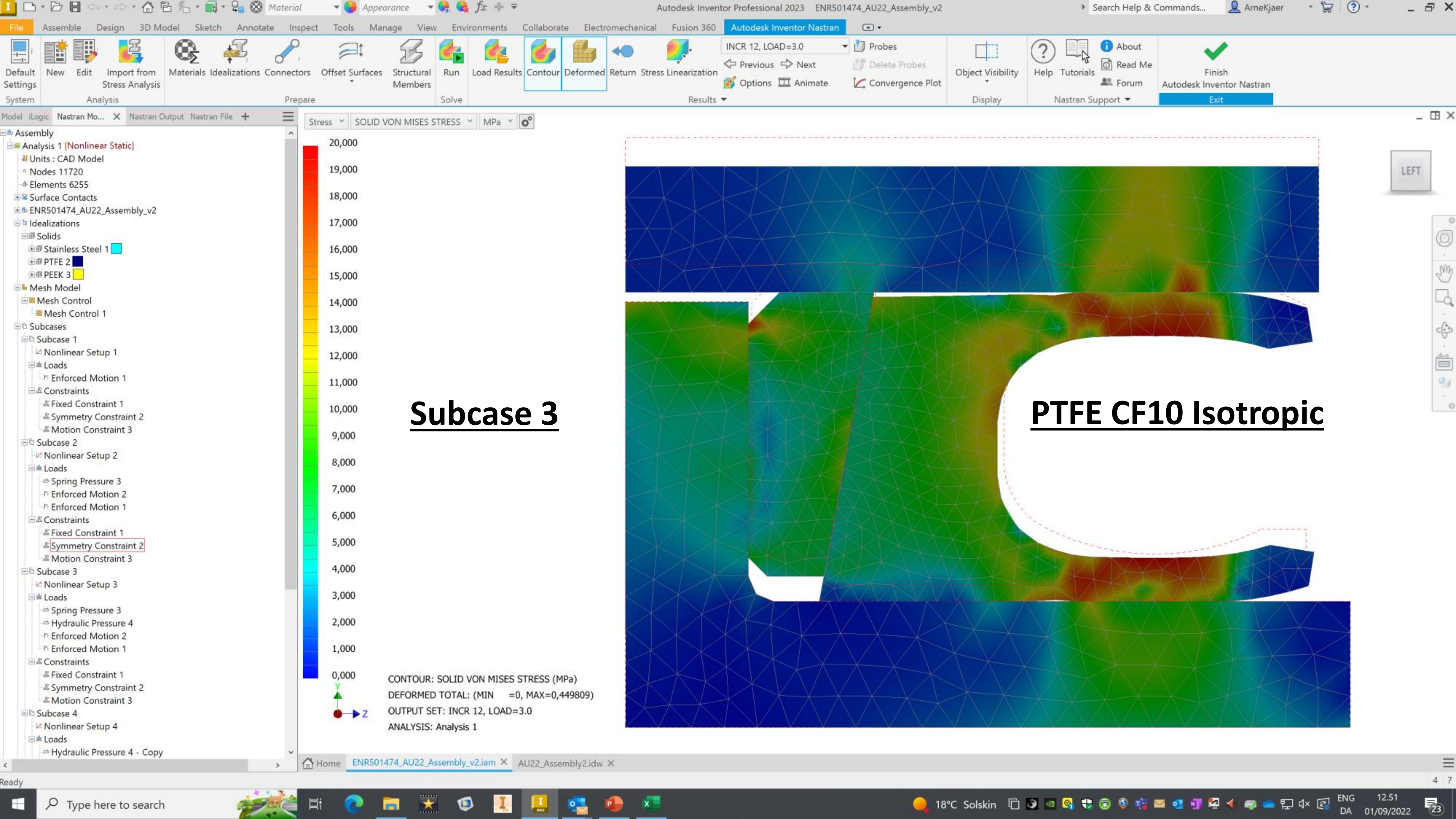
ANALYSIS: Analysis 1

Subcase 2

PTFE CF10 Isotropic




Subcase 3
PTFE CF10 Isotropic
Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Stress
SOLID VON MISES STRESS
MPa
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Assembly
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Surface Contacts
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Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
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Motion Constraint 3
Subcase 2
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Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
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Spring Pressure 3
Hydraulic Pressure 4
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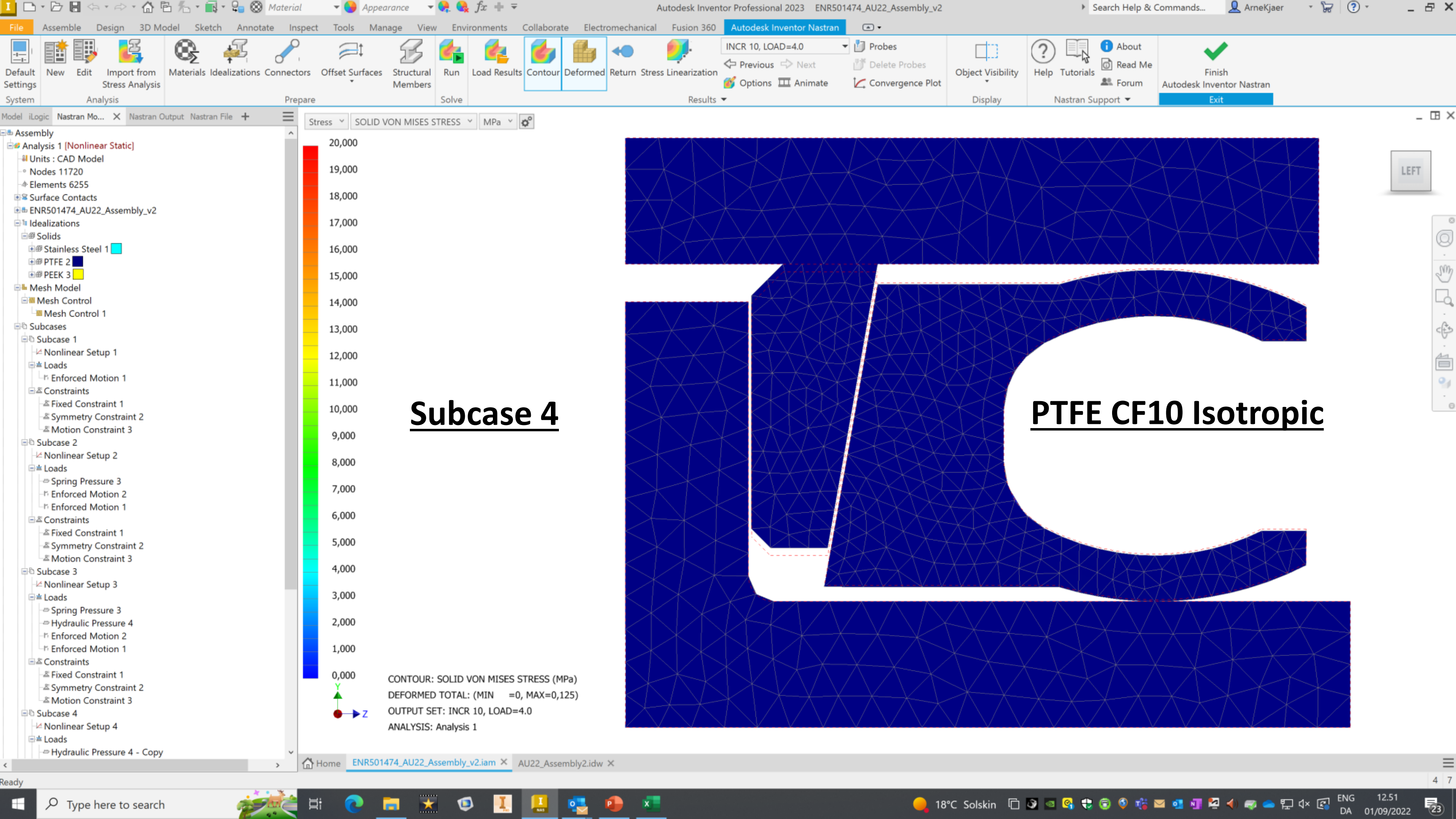
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy


Subcase 4
PTFE CF10 Isotropic
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Stress
SOLID VON MISES STRESS
MPa
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INCR 10, LOAD=4.0
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
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Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
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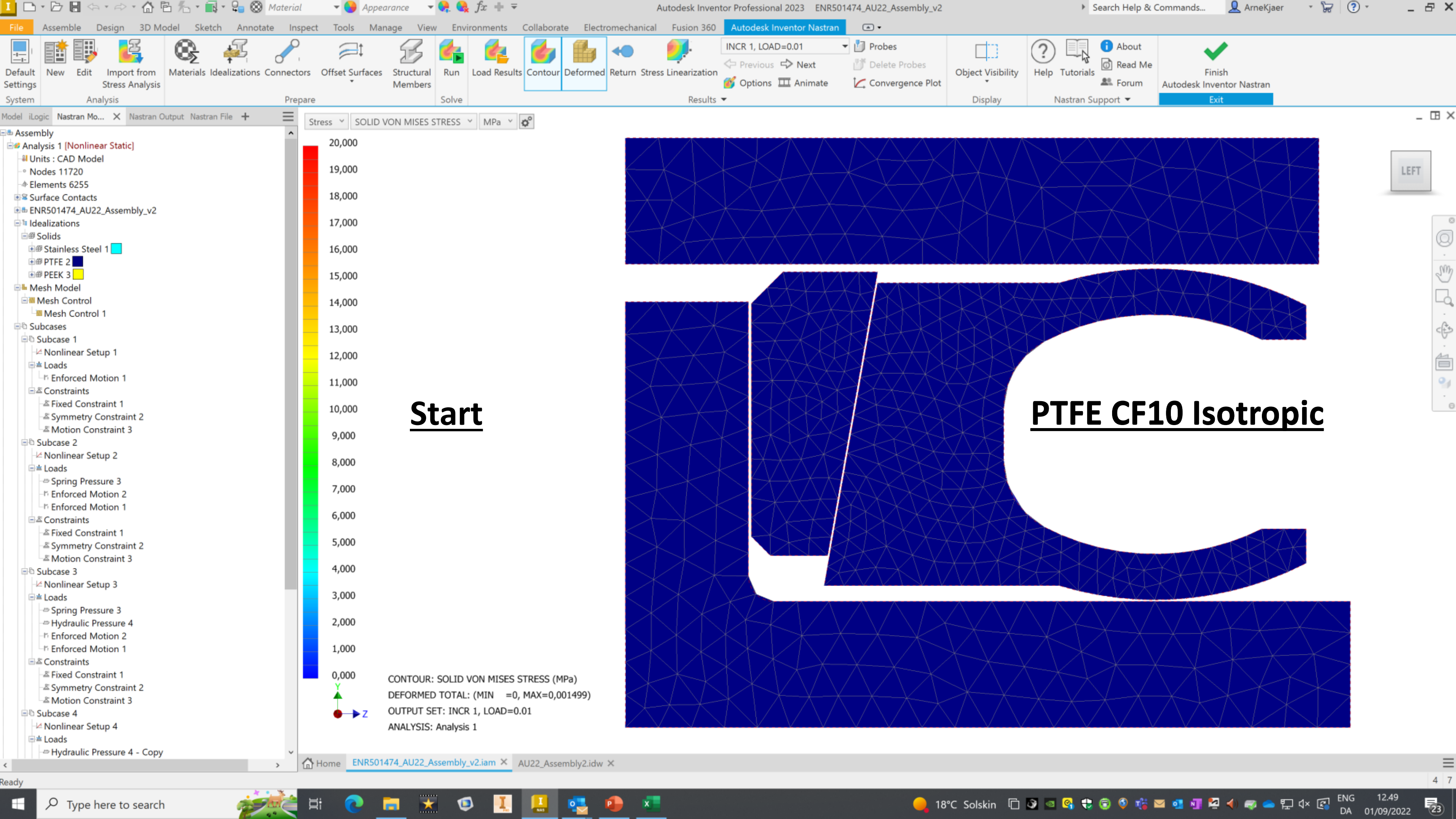
AU22_Assembly2.idw
Ready



Start
PTFE CF10 Isotropic
Stress
SOLID VON MISES STRESS
MPa
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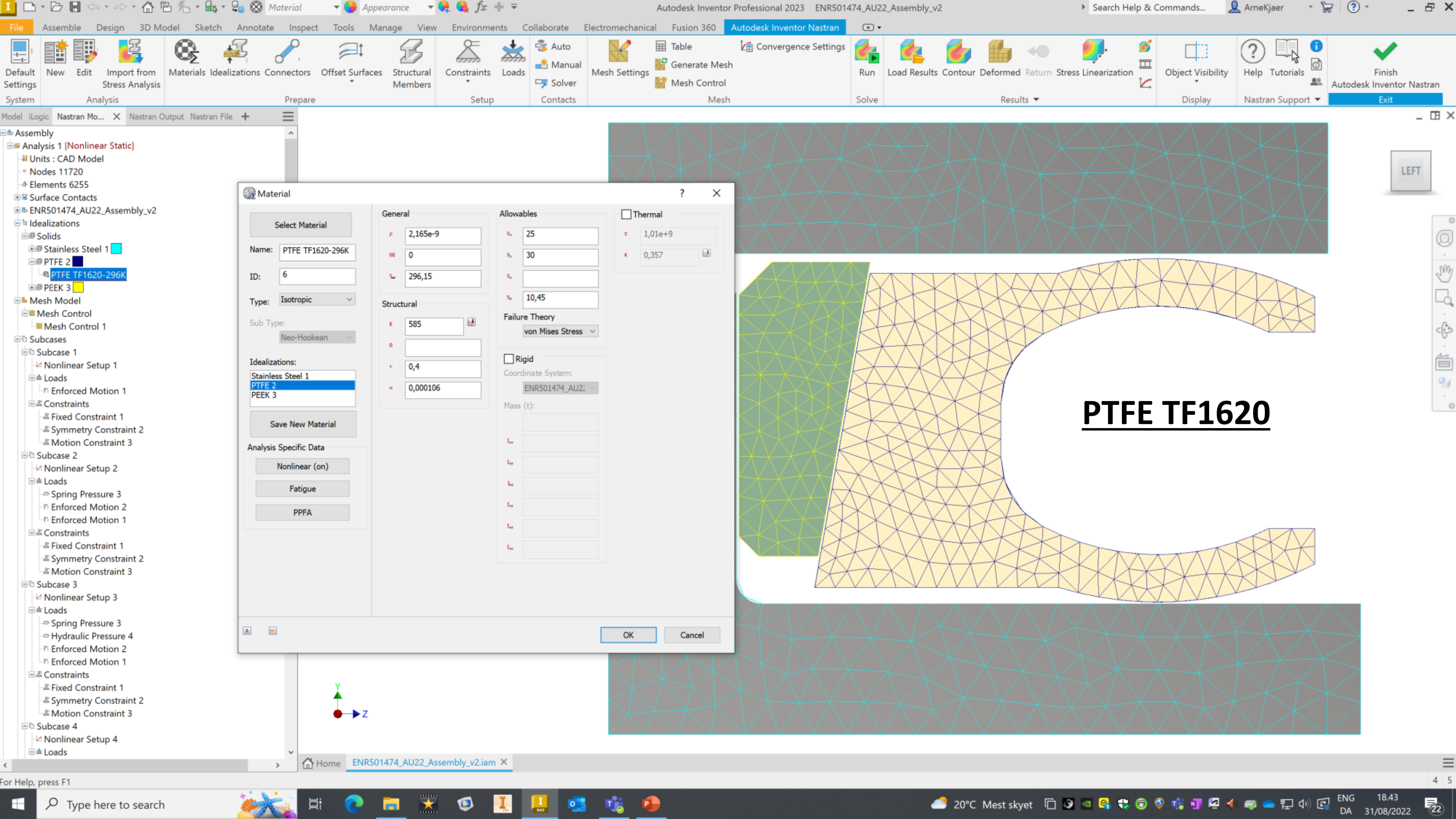
ANALYSIS: Analysis 1



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Autodesk Inventor Nastran
Assembly
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PTFE TF1620-296K
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
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Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Material
Select Material
Name: PTFE TF1620-296K
ID: 6
Type: Isotropic
Sub Type: Neo-Hookean
Idealizations:
Stainless Steel 1
PTFE 2
PEEK 3
Save New Material
Analysis Specific Data
Nonlinear (on)
Fatigue
PPFA
General
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296,15
Structural
585
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0,000106
Allowables
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30
10,45
Failure Theory
von Mises Stress
Rigid
Coordinate System:
Mass (t):
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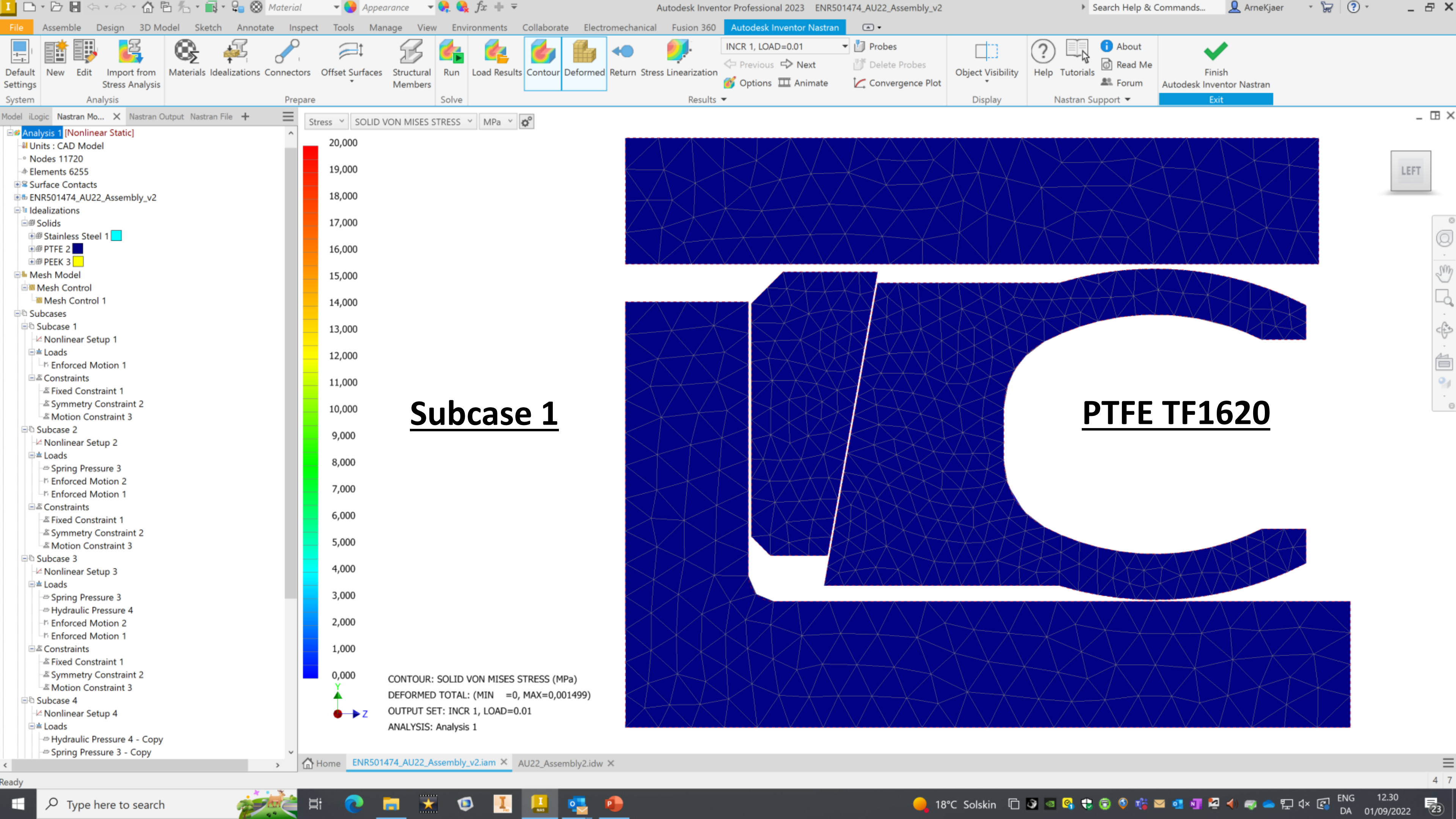
ENR501474_AU22_Assembly_v2.iam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Stress
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Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
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Subcase 1
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Loads
Enforced Motion 1
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Enforced Motion 2
Enforced Motion 1
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Hydraulic Pressure 4
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Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
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Loads
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Spring Pressure 3 - Copy
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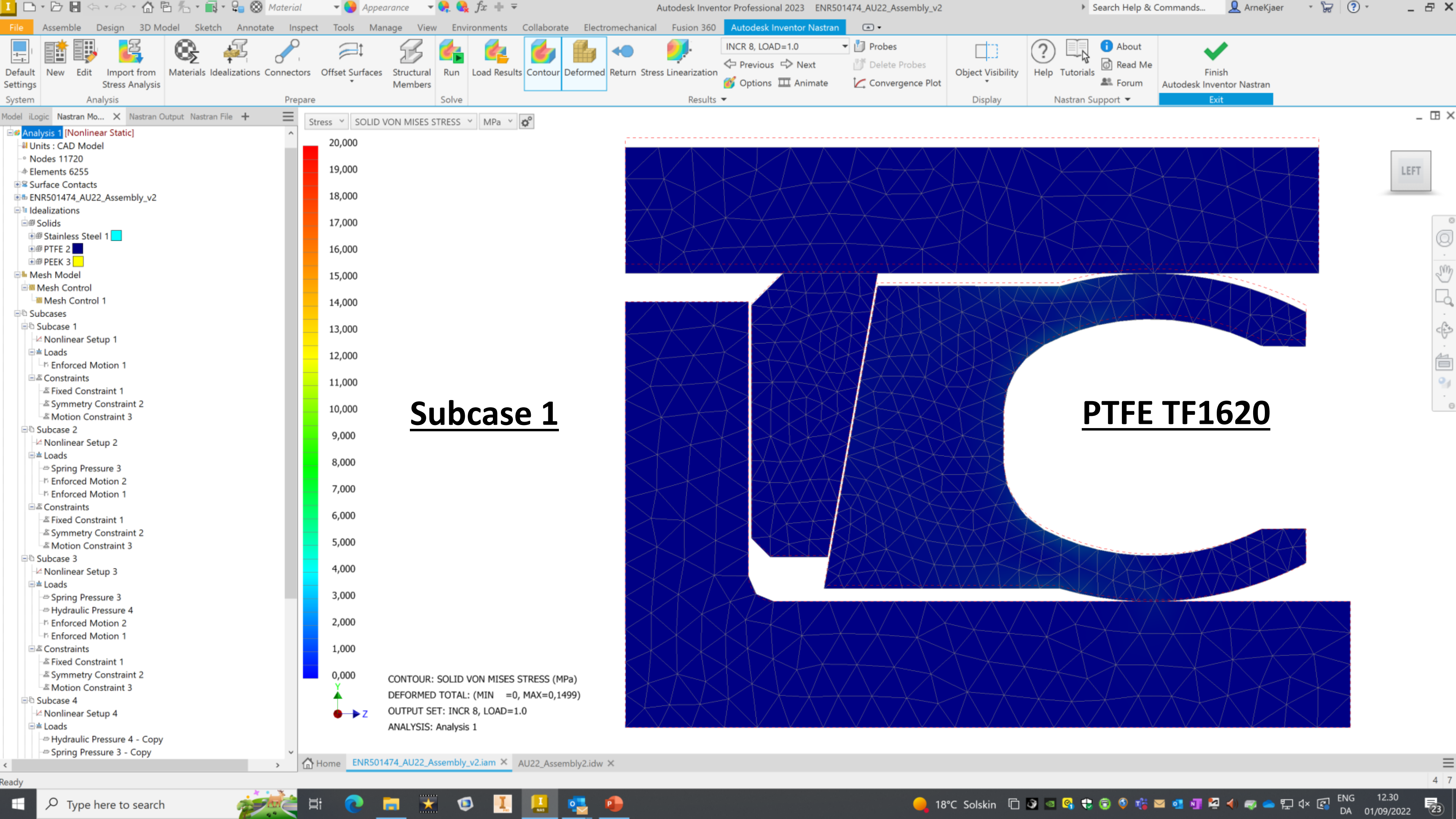
Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Autodesk Inventor Nastran
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
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Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
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Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Stress
SOLID VON MISES STRESS
MPa
INCR 8, LOAD=1.0
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Subcase 1
PTFE TF1620
CONTOUR: SOLID VON MISES STRESS (MPa)
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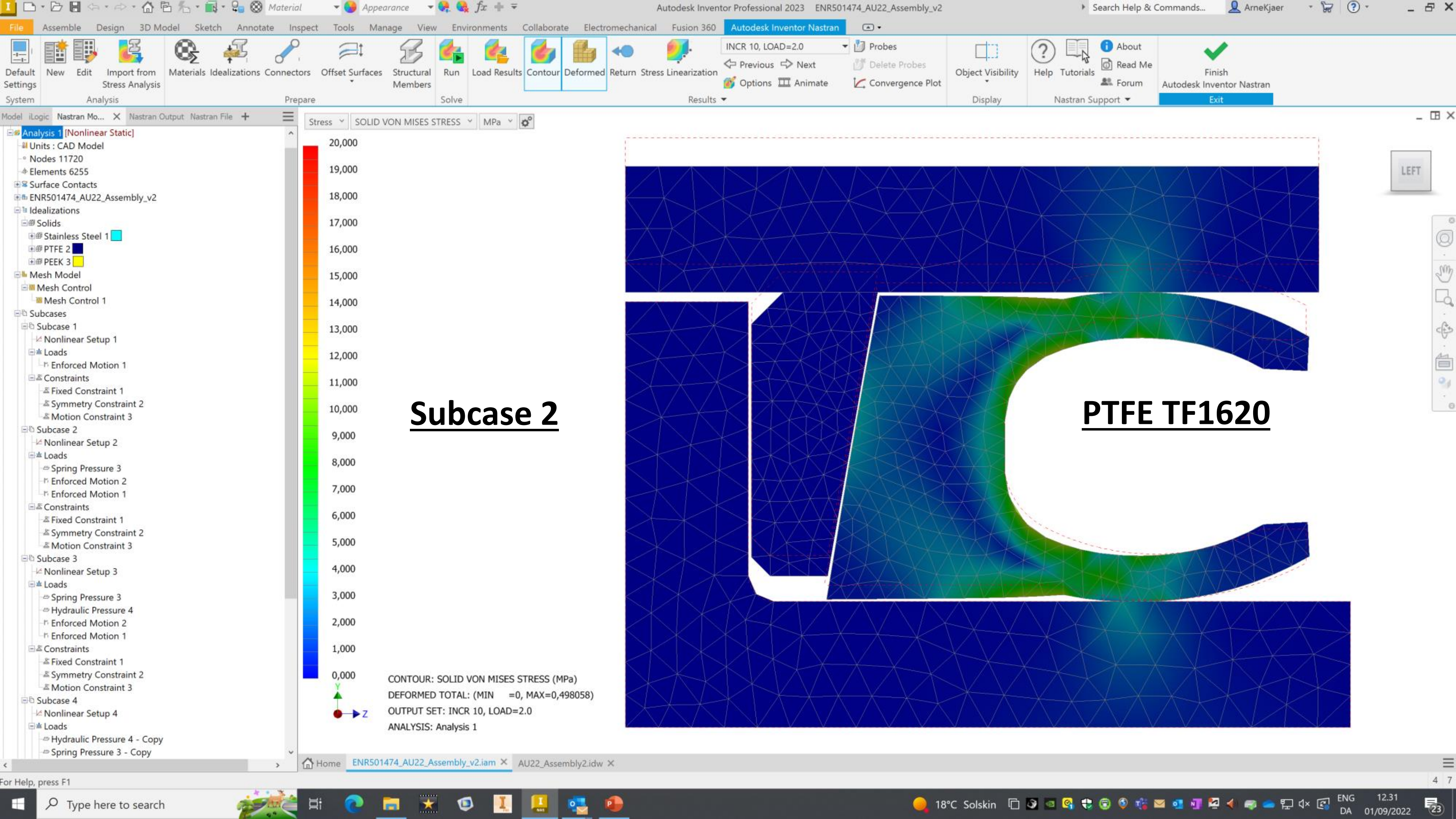
ENR501474_AU22_Assembly_v2.iam
AU22_Assembly2.idw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Autodesk Inventor Nastran
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Stress
SOLID VON MISES STRESS
MPa
INCR 10, LOAD=2.0
20,000
19,000
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Subcase 2
PTFE TF1620
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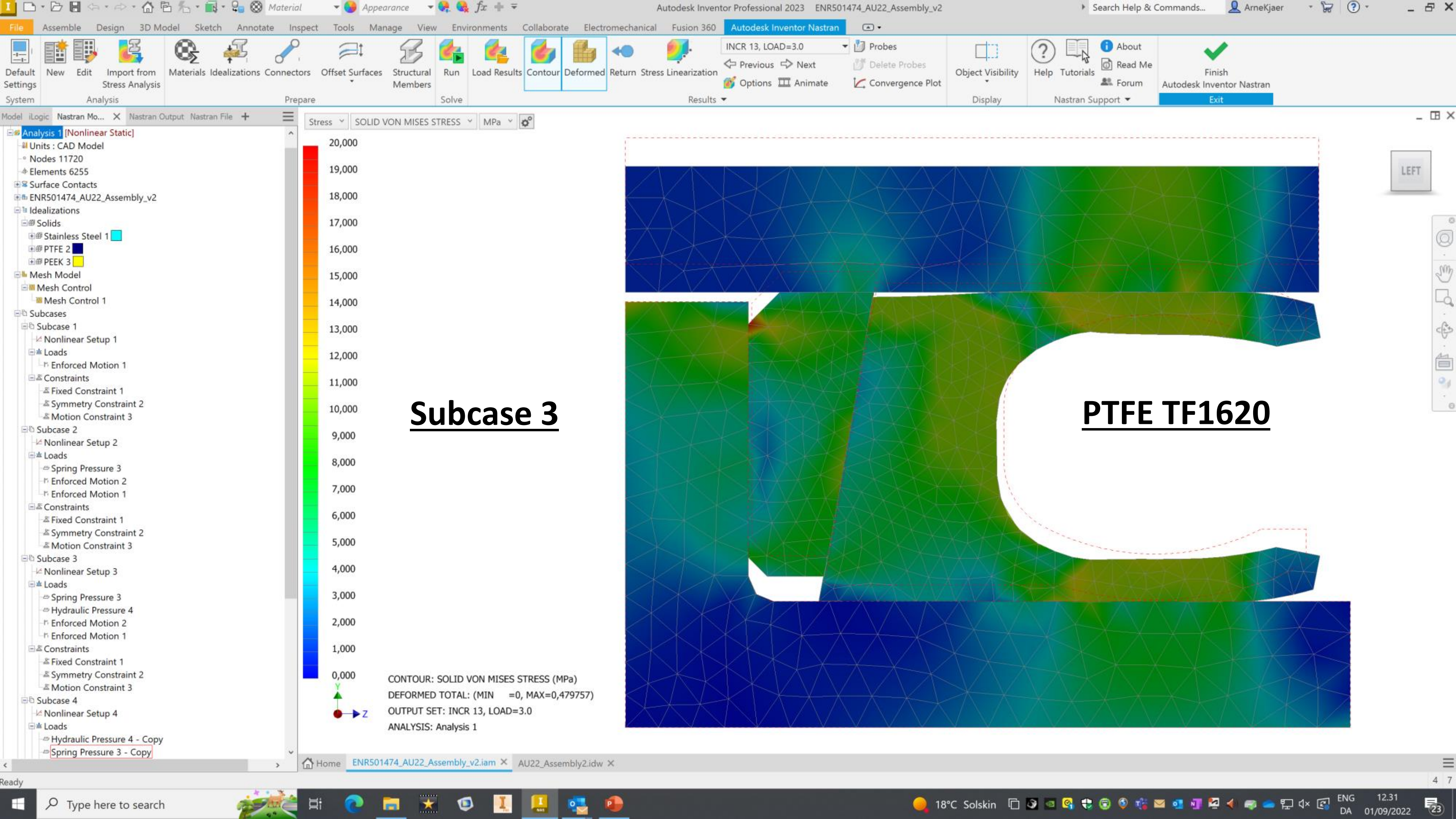
ENR501474_AU22_Assembly_v2.iam
AU22_Assembly2.idw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Autodesk Inventor Nastran
Stress
SOLID VON MISES STRESS
MPa
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
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0,000
Subcase 3
PTFE TF1620
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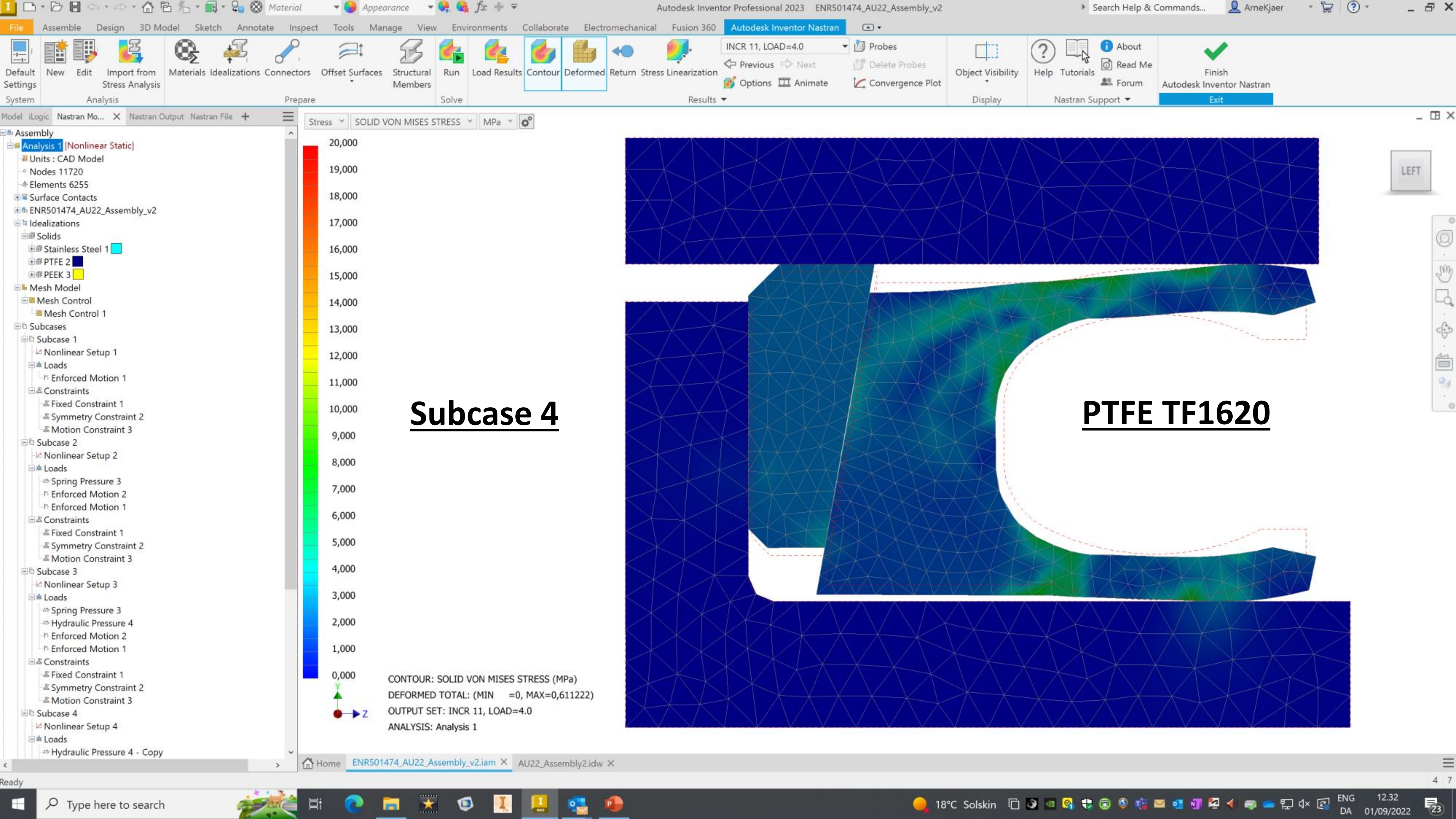
ANALYSIS: Analysis 1


Subcase 4
PTFE TF1620
Stress
SOLID VON MISES STRESS
MPa
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Assembly
Analysis 1 [Nonlinear Static]
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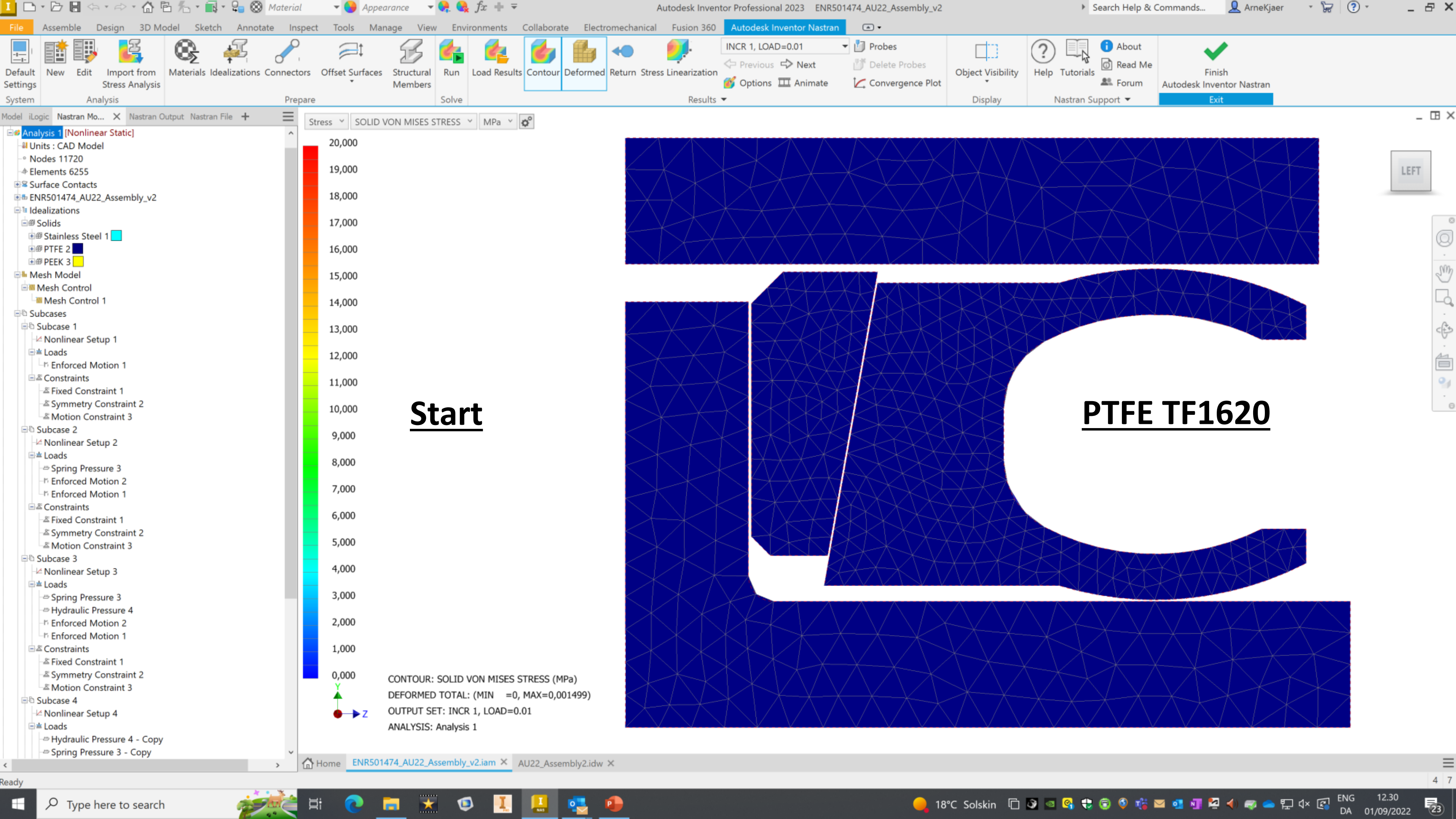
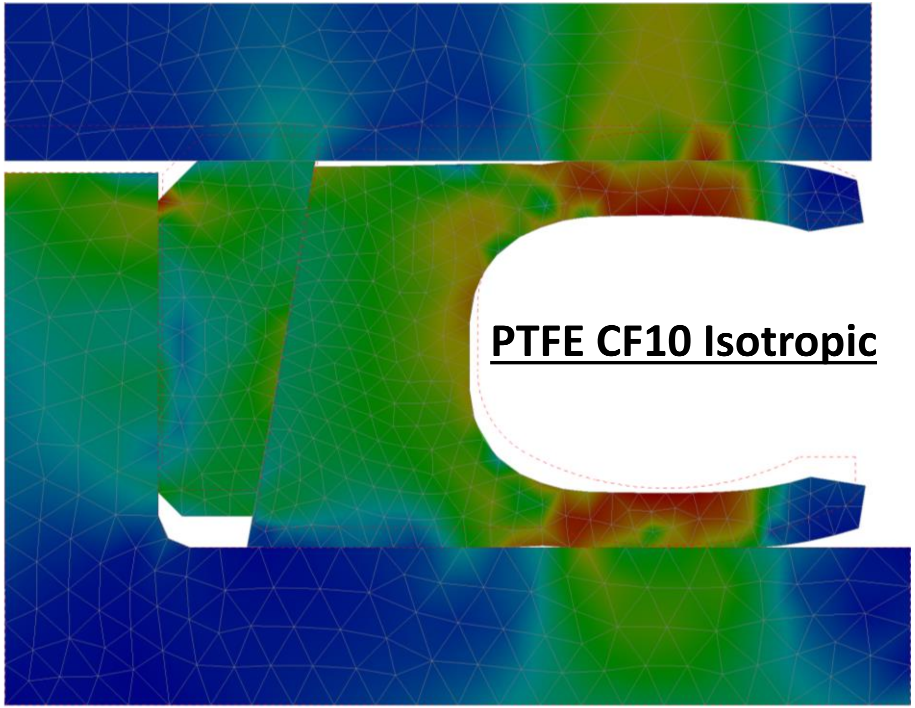
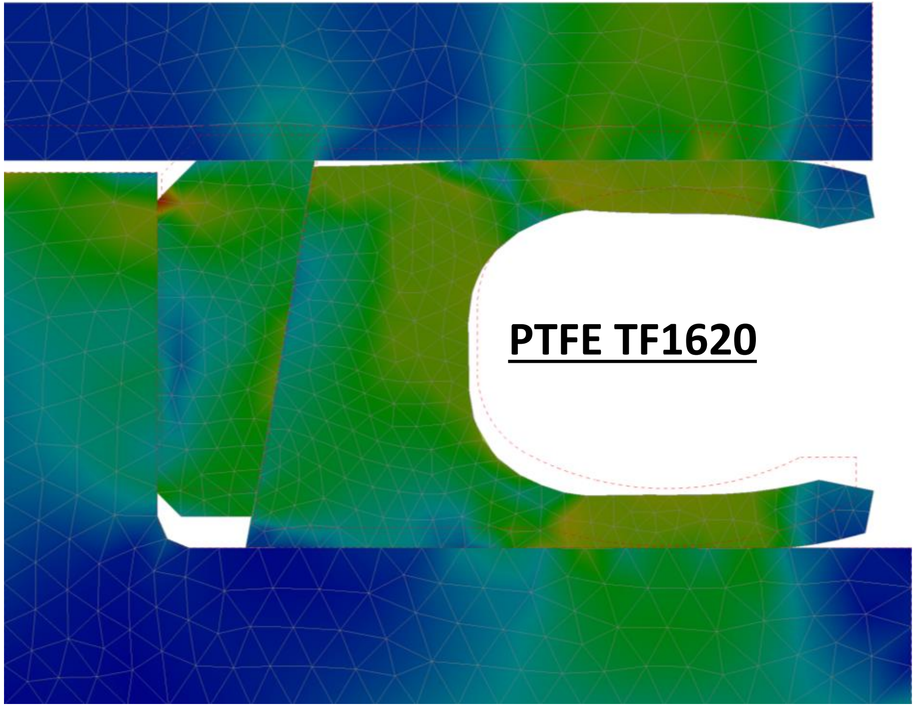
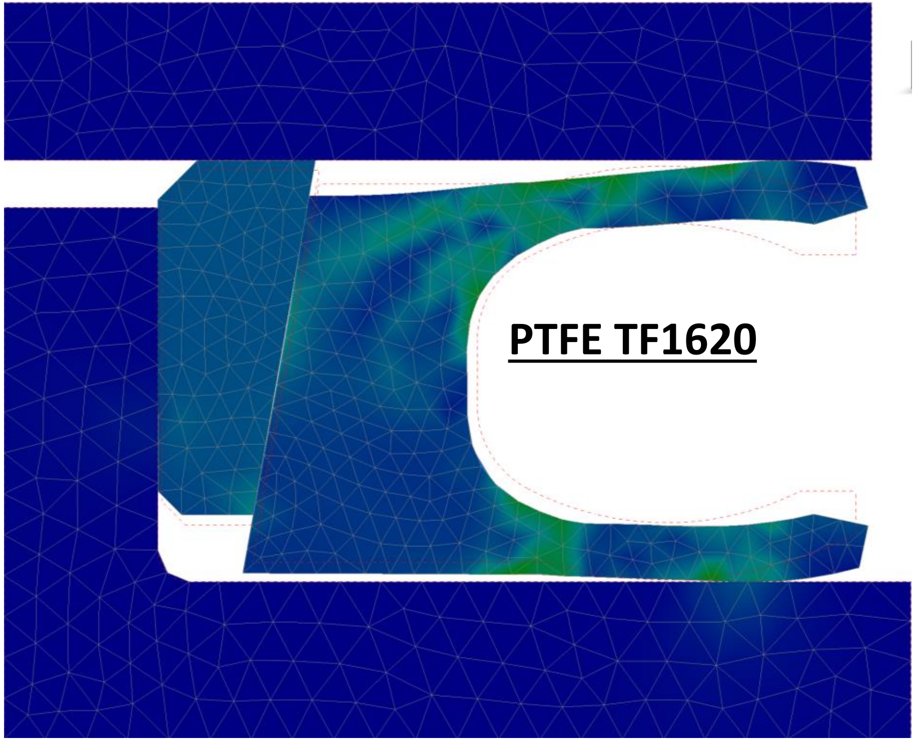
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
INCR 11, LOAD=4.0
ENR501474_AU22_Assembly_v2.iam
AU22_Assembly2.idw


Autodesk Inventor Professional 2023 ENR501474_AU22_Assembly_v2
Autodesk Inventor Nastran
Analysis 1 [Nonlinear Static]
Units : CAD Model
Nodes 11720
Elements 6255
Surface Contacts
ENR501474_AU22_Assembly_v2
Idealizations
Solids
Stainless Steel 1
PTFE 2
PEEK 3
Mesh Model
Mesh Control
Mesh Control 1
Subcases
Subcase 1
Nonlinear Setup 1
Loads
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 2
Nonlinear Setup 2
Loads
Spring Pressure 3
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 3
Nonlinear Setup 3
Loads
Spring Pressure 3
Hydraulic Pressure 4
Enforced Motion 2
Enforced Motion 1
Constraints
Fixed Constraint 1
Symmetry Constraint 2
Motion Constraint 3
Subcase 4
Nonlinear Setup 4
Loads
Hydraulic Pressure 4 - Copy
Spring Pressure 3 - Copy
Stress
SOLID VON MISES STRESS
MPa
INCR 1, LOAD=0.01
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0,000
Start
PTFE TF1620
CONTOUR: SOLID VON MISES STRESS (MPa)
DEFORMED TOTAL: (MIN =0, MAX=0,001499)
OUTPUT SET: INCR 1, LOAD=0.01
ANALYSIS: Analysis 1
ENR501474_AU22_Assembly_v2.iam
AU22_Assembly2.idw


PTFE CF10 Isotropic


PTFE TF1620


PTFE CF10 Isotropic

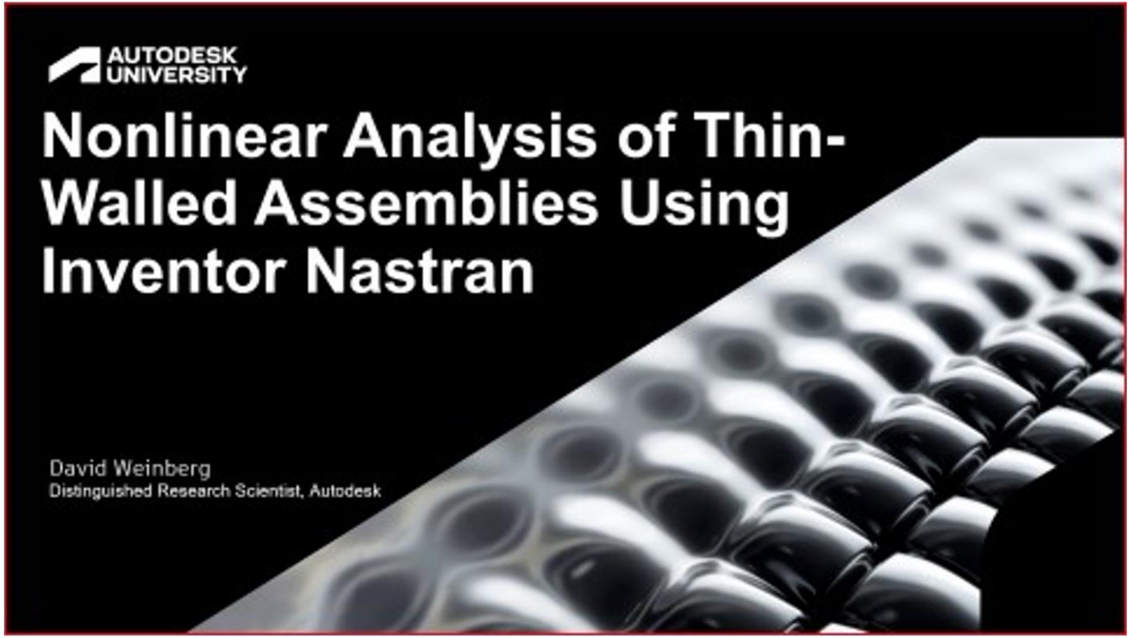

PTFE TF1620

We are now happy to answer your QUESTIONS ☺☺☺

For More Information Please Attend…

- The Presentation will cover additional information on contact and nonlinear static analysis in Inventor Nastran

- Wednesday, 28 Sep, 430pm



Thank you

More Materials

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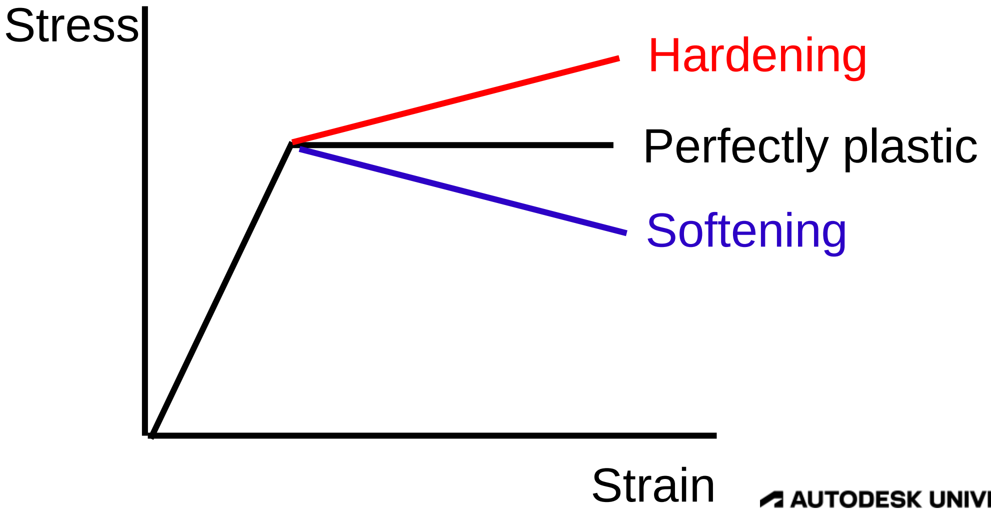
Mechanical and Aerospace Engineering
University of Florida

Strain Hardening, Work Hardening

- More stress is required to continue yielding
- Yield strength is a function of plastic strain
- Yield strength ~ Plastic strain

$$\sigma_Y(\varepsilon^p)$$

Hardening model



Isotropic hardening model

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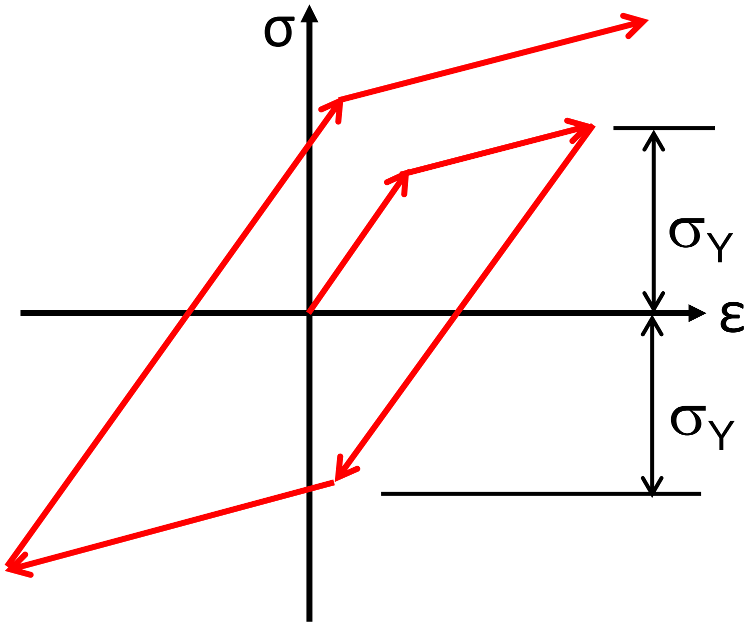
- Yield strength increases for both tension and compression

- Yield strength ~ Plastic strain

$$\sigma_Y(\varepsilon^p) = \sigma_Y^0 + H\varepsilon^p$$

Initial yield strength (σ_Y^0) — Plastic modulus (H)



- Yield condition

$$|\sigma| \le \sigma_Y(\varepsilon^p)$$

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Kinematic hardening model

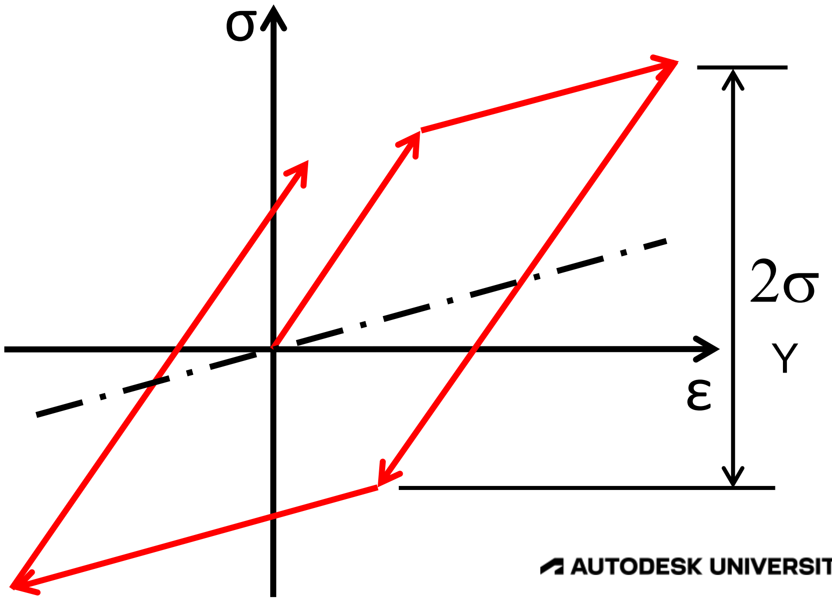
- The range of yield strength remains constant
- The center of yield strength moves along with plastic strain
- Center of yield ~ plastic strain

$$\alpha(\varepsilon^p) = H\varepsilon^p$$

Center of yield   Plastic modulus

- Yield condition

$$\left|\sigma - \alpha(\varepsilon^p)\right| \le \sigma_Y^0$$



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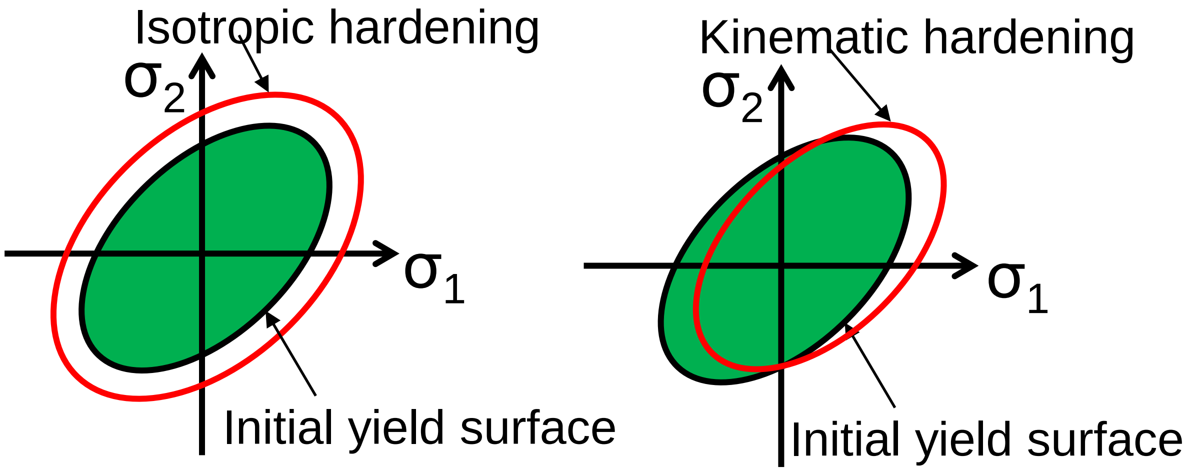
Hardening model in 3D space

- Yield region as a surface (yield surface)
- Isotropic hardening: the radius of yield surface increases
- Kinematic hardening: the center of yield surface moves



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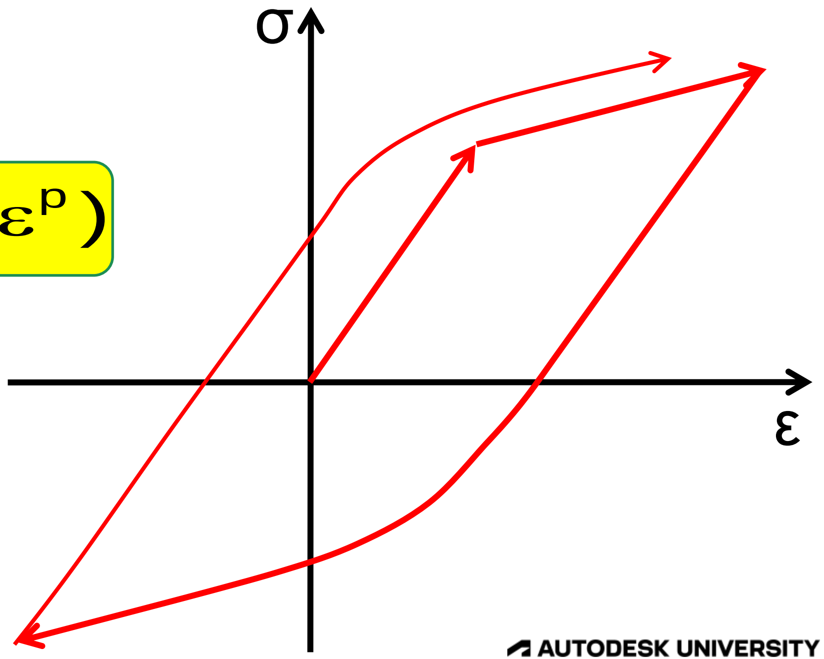
Bauschinger effect

- Many metals shows a reduced yield strength when loading direction changes
  - Due to the accumulation of dislocation
- Combined hardening model

$$\left|\sigma - \beta\alpha(\varepsilon^p)\right| \le (1-\beta)\sigma_Y(\varepsilon^p)$$

$$0 \le \beta \le 1$$

- $\beta = 0$: Isotropic hardening
- $\beta = 1$: Kinematic hardening



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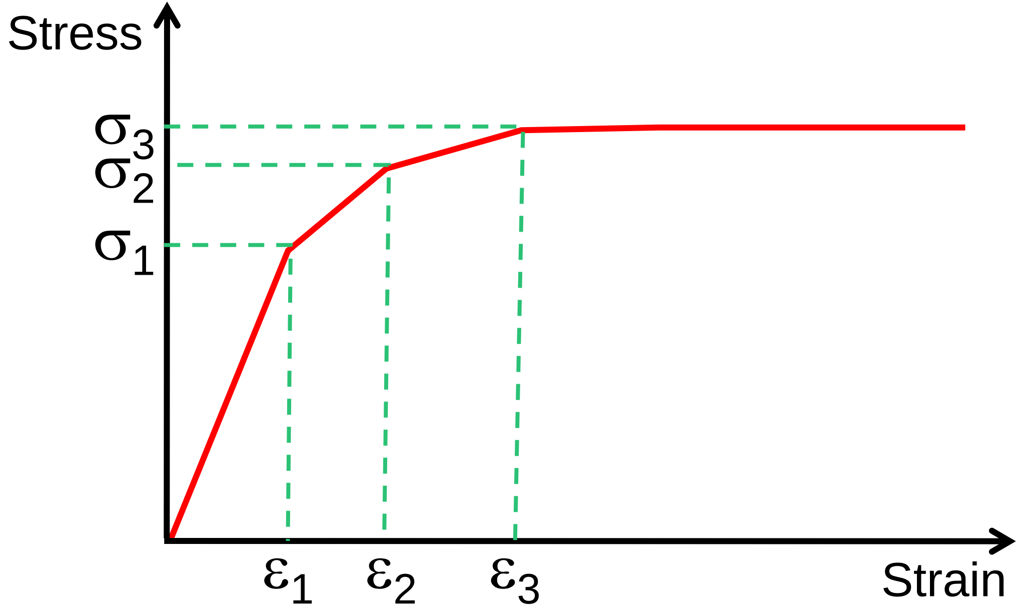
Strain-hardening model in Nastran

- Incrementally linear hardening model

- The slope of initial yield (e_1, s_1) must be Young's modulus



Nastran Material Model from your own test data

Isotropic Plastic Material Model – Nastran Material Data Input

In order to build up your own polymer material model you will need some information's regarding your polymer material behavior

In this example I am showing here I build up a polymer material model representing, a PTFE material reinforced with Carbon Fiber

Most of the needed information's you will have to measure yourself or have a professional laboratory to measure the data for you

Here its very important to decide on how many different temperatures and testing speed you will need to measure in order to cover the range of your application

In order to have relevant information's we have also produced the test parts in order to have full knowledge about the production parameters which in many cases have an influence on the internal structure of the polymer and therefor also the strength

Nastran Material Model from your own test data

Isotropic Plastic Material Model – Nastran Material Data Input

General

- Mass Density
- Damping Coefficient
- Reference Temperature

Allowables

- Tensile Limit
- Compressive Limit
- Shear Limit
- Yield Limit

Structural

- Elastic Modulus (Table with Temperature Dependence)
- Shear Modulus calculated as E/(2*Poissions Ratio)
- Poission's Ratio

Failure Theory

- ○ None
- ● Von Mises Stress
- ○ Principal Stress

Nastran Material Model from your own test data

Isotropic Plastic Material Model – Nastran Material Data Input

Thermal

- Specific Heat
- Thermal conductivity

Nastran Material Model from your own test data

Isotropic Plastic Material Model – Nastran Material Data Input

Hardening Rule

- ● Isotropic
- ○ Kinematic
- ○ Isotropic + Kinematic

Nonlinear

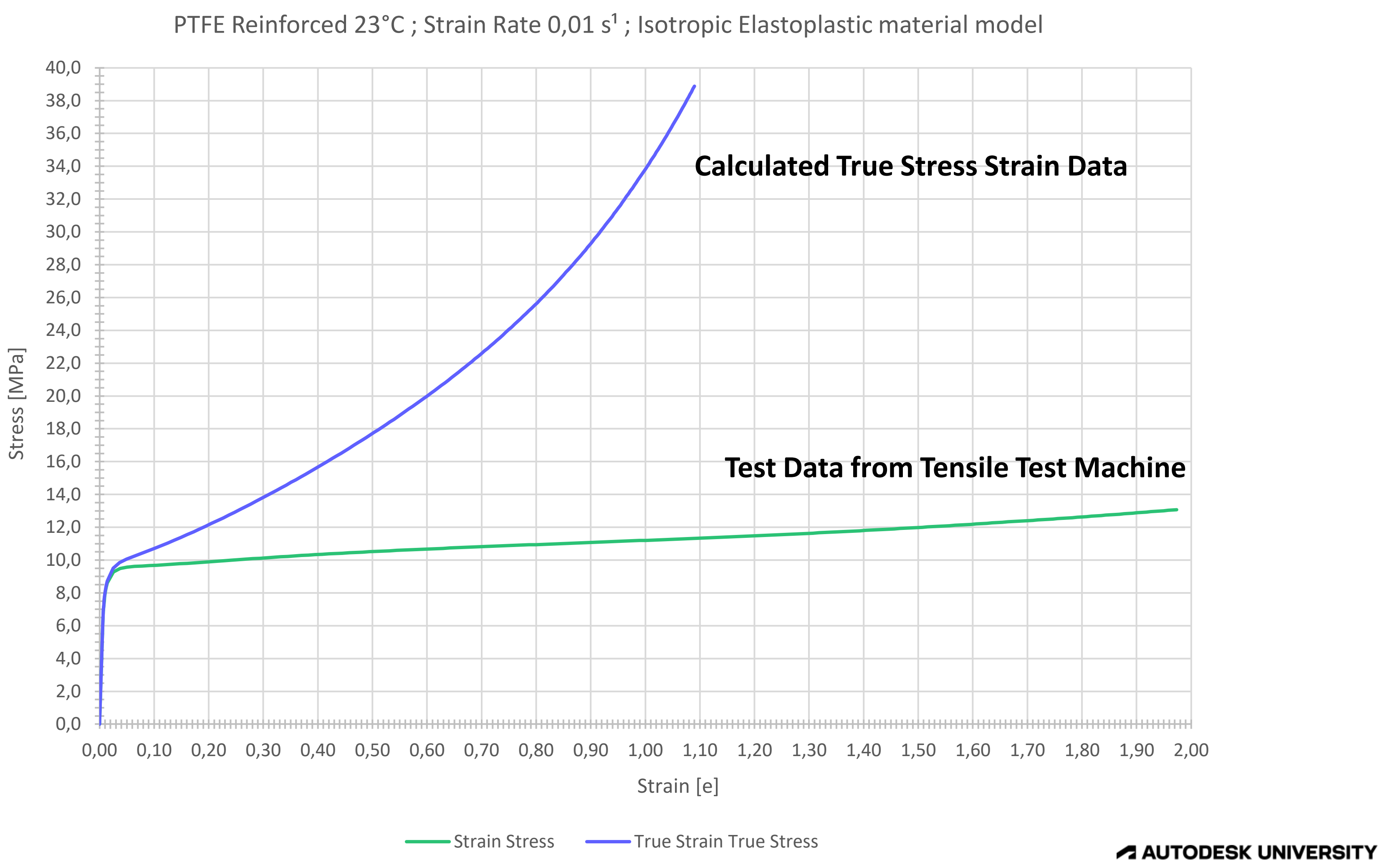
- ○ None
- ○ Nonlinear Elastic
- ○ Elasto-Plastic (Bi-Linear)
- ● Plastic

Yield Criterion

- ● Von Mises
- ○ Tresca
- ○ Mohr – Coulomb
- ○ Drucker – Prager

Data Input

Strain	Stress
0	0
Yield	Yield
xxx	yyy


PTFE Reinforced 23°C ; Strain Rate 0,01 s¹ ; Isotropic Elastoplastic material model
Calculated True Stress Strain Data
Test Data from Tensile Test Machine
Stress [MPa]
Strain [e]
40,0
38,0
36,0
34,0
32,0
30,0
28,0
26,0
24,0
22,0
20,0
18,0
16,0
14,0
12,0
10,0
8,0
6,0
4,0
2,0
0,0
0,00
0,10
0,20
0,30
0,40
0,50
0,60
0,70
0,80
0,90
1,00
1,10
1,20
1,30
1,40
1,50
1,60
1,70
1,80
1,90
2,00
Strain Stress
True Strain True Stress
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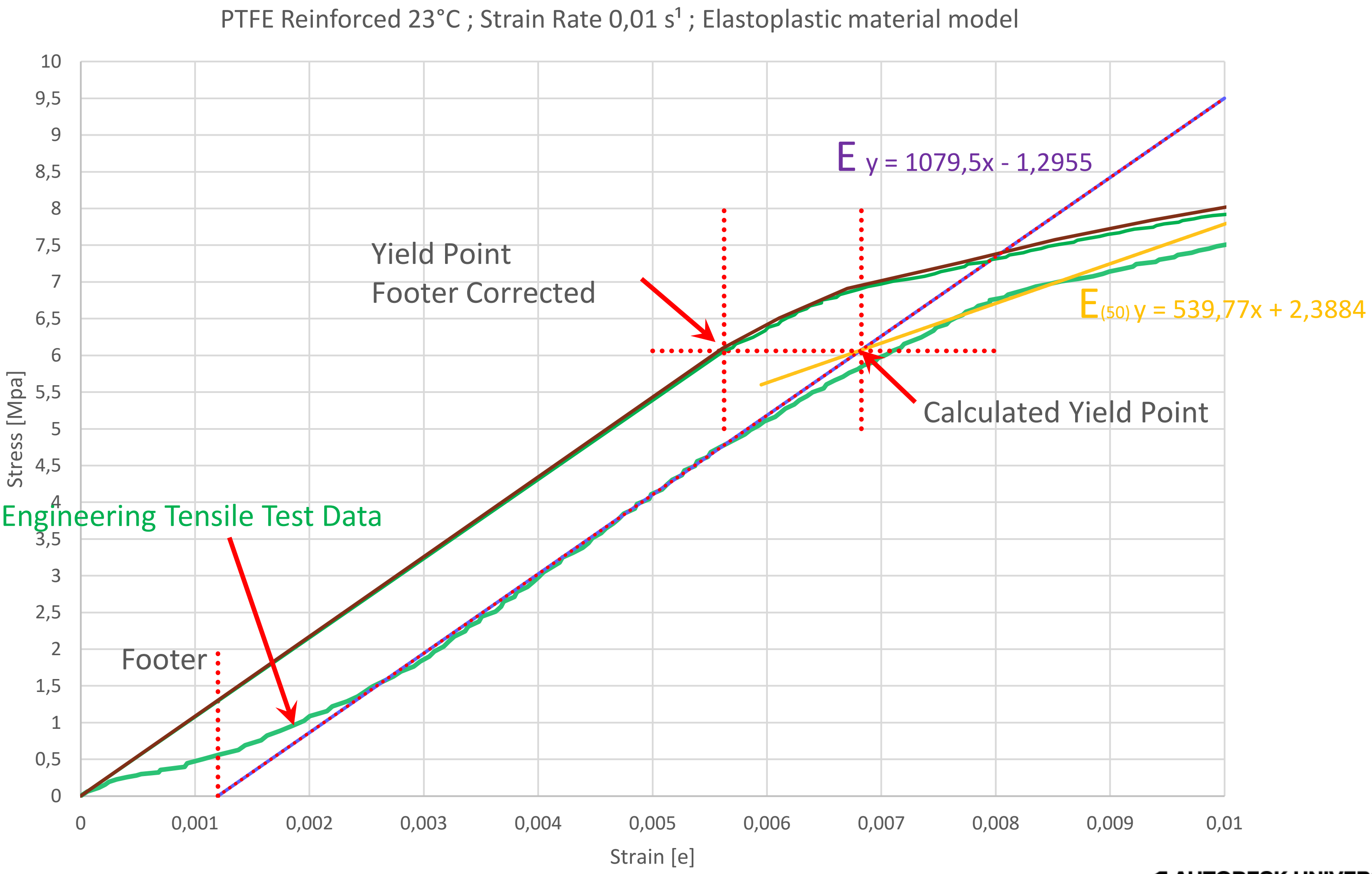

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Nastran Material Model from your own test data

Isotropic Plastic Material Model

- Using your Engineering Tensile Test Data measured at a temperature and strain rate
- Insert the data in an empty Excel Sheet and make a graph of the stress strain curve
- Overlay the curve with a line to illustrate the Youngs Modulus or Elastic Modulus
- Make a line with (I typically us 50% of the Elastic Modulus) as tangent to the measured curve
- Excel can show you the mathematic of the two lines and from those you calculate the crossing point between the lines this is the calculated Yield Point
- Also calculate the Elastic modulus lines crossing at y=0, this it the footer
- Now you correct the measured data with the footer offset

Nastran Material Model from your own test data

Isotropic Plastic Material Model

- Now you correct the measured data with the footer offset and make the first point @ 0;0 and the second point as the corrected Yield Point
- The rest of the curve I typically reduce to have only 1 point for each 100 measured points
- I then calculates the Trues Stress Strain curve using the recognized transformation
- True Strain = LN(1+ Engineering Strain)
- Trues Stress = Engineering Stress * (1 + Engineering Strain)
- The Nastran Input will then be Trues Strain ; True Stress

Thank you

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