

Rack and Pinion Analysis

(Marine Jacking Gear)

7 Applied Load Cases

4/11/2022

KTO Solutions, LLC

Summary

- Rack and Pinion tooth contact analysis was performed at 7 positions from the pinion tooth tip to near the root.
- The contact von Mises stress for the deformable contact is in the range of 1500-2200MPa for the pinion and 1300-1700MPa on the rack.
- These stress values fall within the limits for a hardened A514 steel gear tooth face*.

*Allowable Contact Stresses in Jacking Gear Units Used in the Offshore Industry, A.N. Montestruc, Gear Technology, May 2010

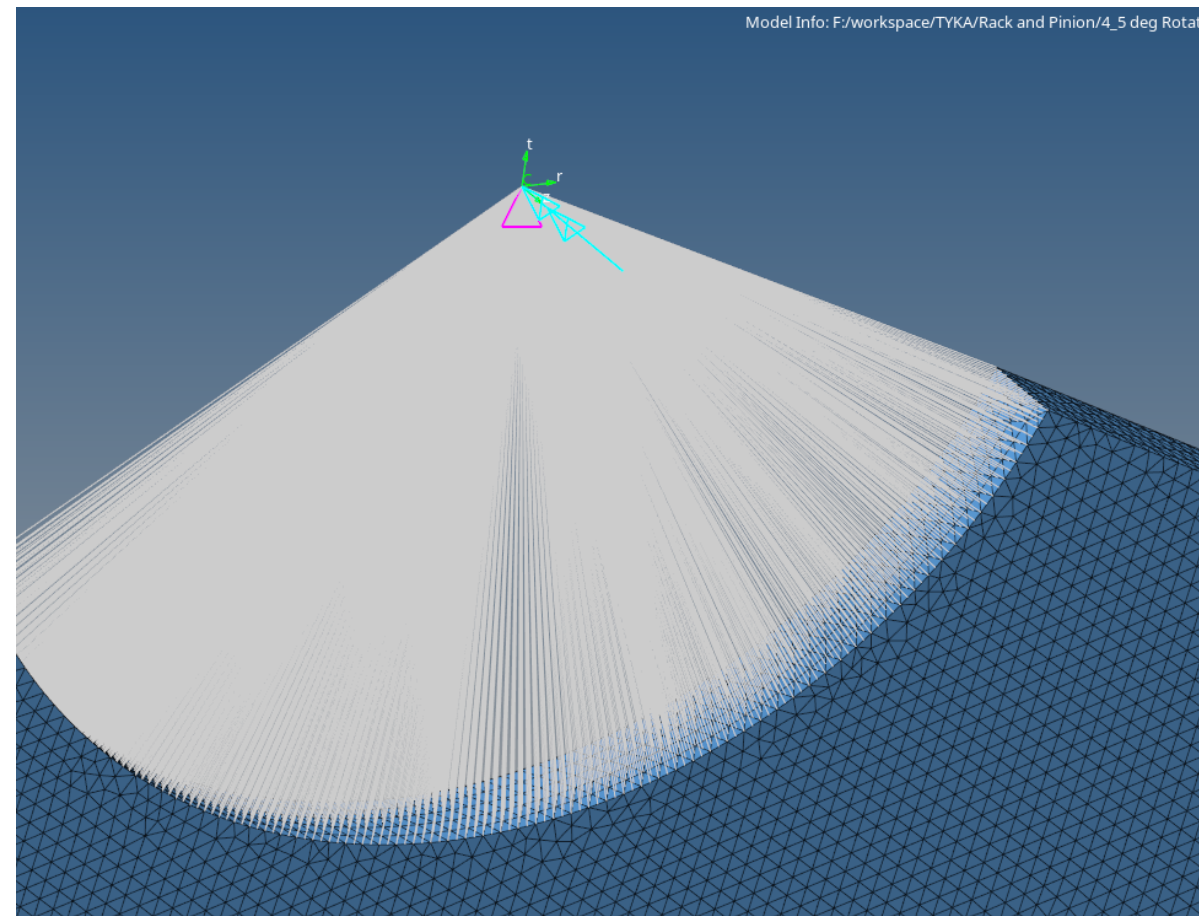
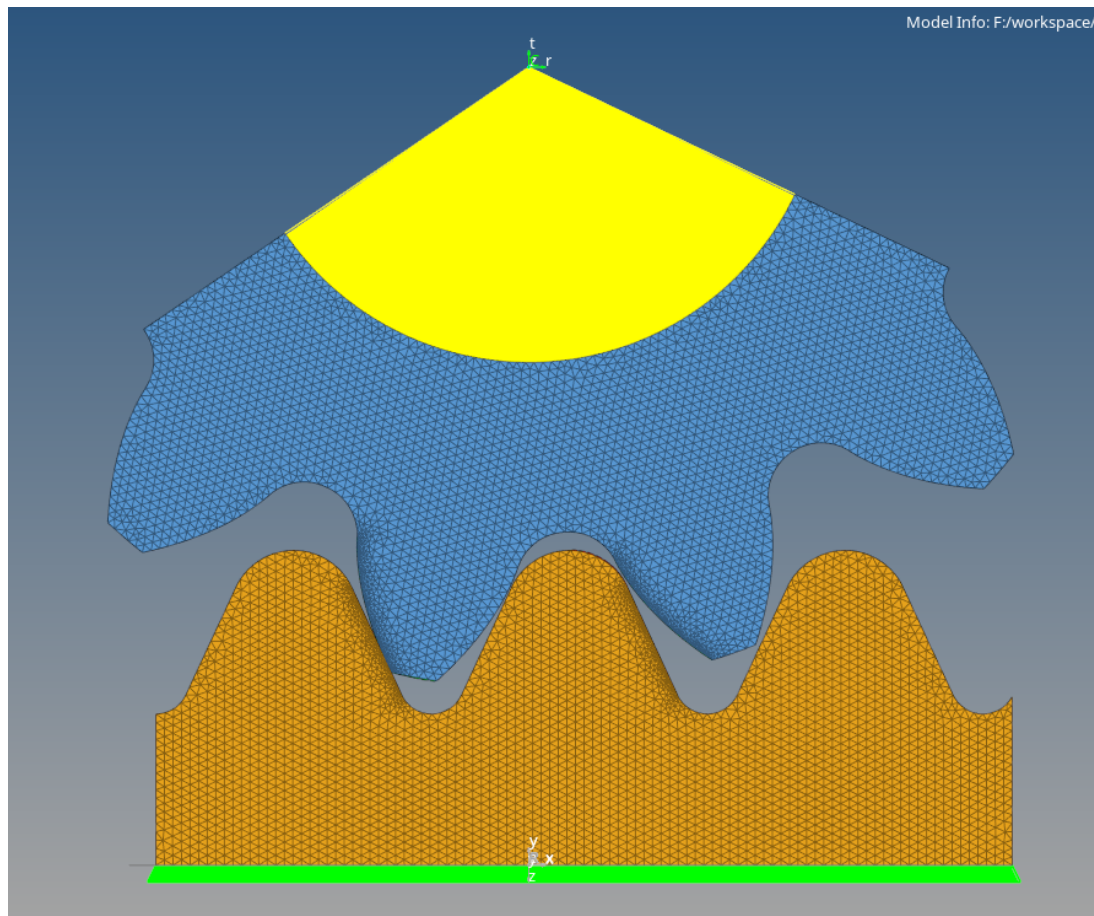
Model Set Up

- Material: ASTM A514 Quenched and Tempered Steel
Typical Properties: E = 210,000MPa
Yield Stress: 690MPa
UTS: 900MPa
Poissons: 0.33
Density: 7.89E-9 Megagram/mm³
- Material Brinnell hardness not considered for contact analysis – linear material properties assumed to generate maximum stress values.
- RBE3 element to connect the pinion to its “center”. An RBE transfers force and moments but does not add stiffness to the solid elements.
- Node to Surface contact applied on 1mm edge length TET10 elements.
- Optistruct Implicit solutions generated using a Non-Linear Quasi Static solver for the contact formulation.

Load Case Boundary Conditions

- Model reduced to 4 pinion teeth and 3 rack teeth to reduce solution time.
 - Rack and pinion width reduced to 1" width (25.4mm)
 - Torque reduced to from 522,870 lbf-ft to 65,935 lbf-ft (8.87E07 N-mm), applied at the center of the pinion.
- Pinion uses axisymmetric boundary conditions – nodes can only rotate about the gear center using a cylindrical CSYS.
- The rack bottom surface is constrained in all 6 DOF.

Mesh and BCs



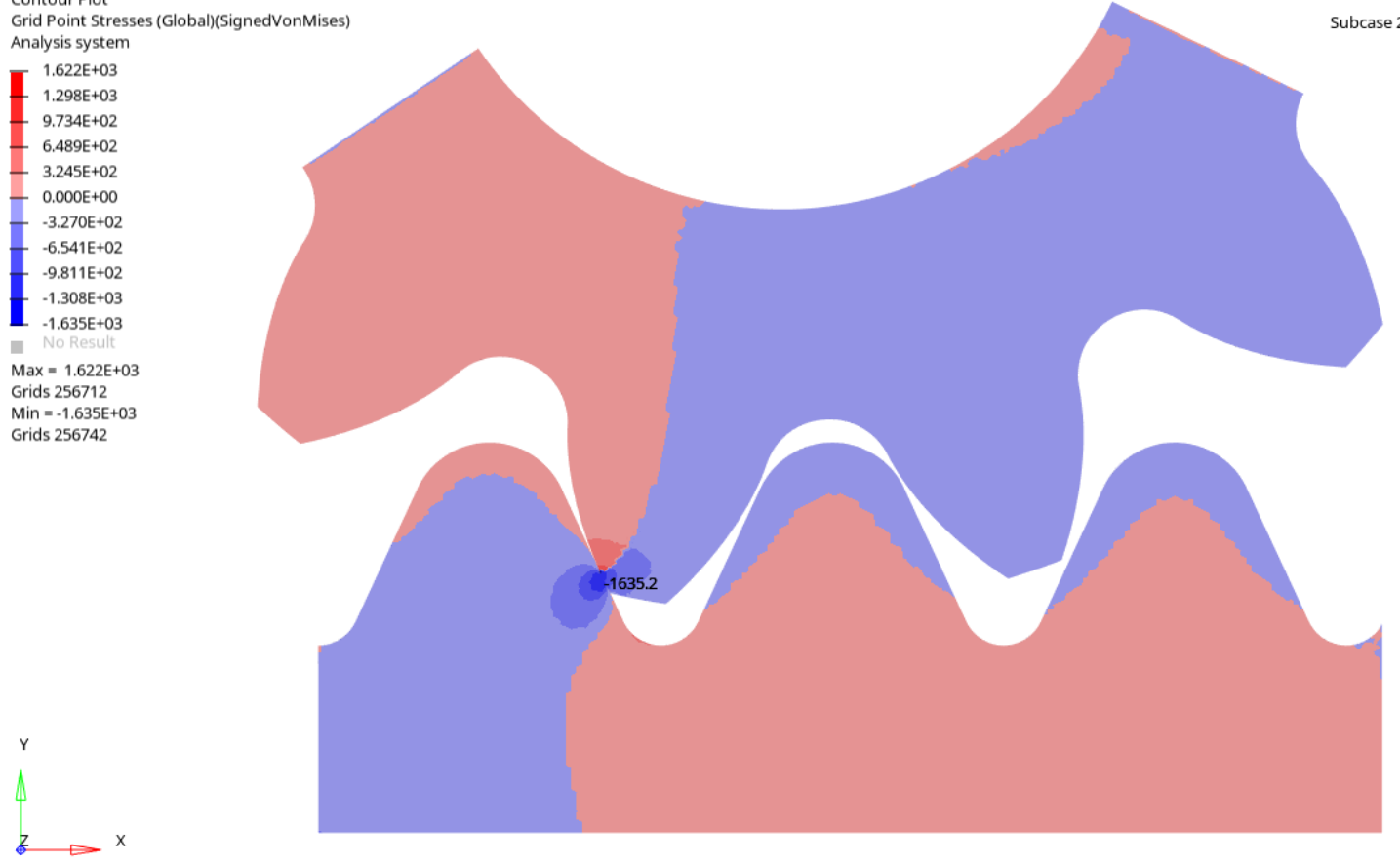
4.5 degrees rotation from tip contact

Contour Plot
Grid Point Stresses (Global)(SignedVonMises)
Analysis system

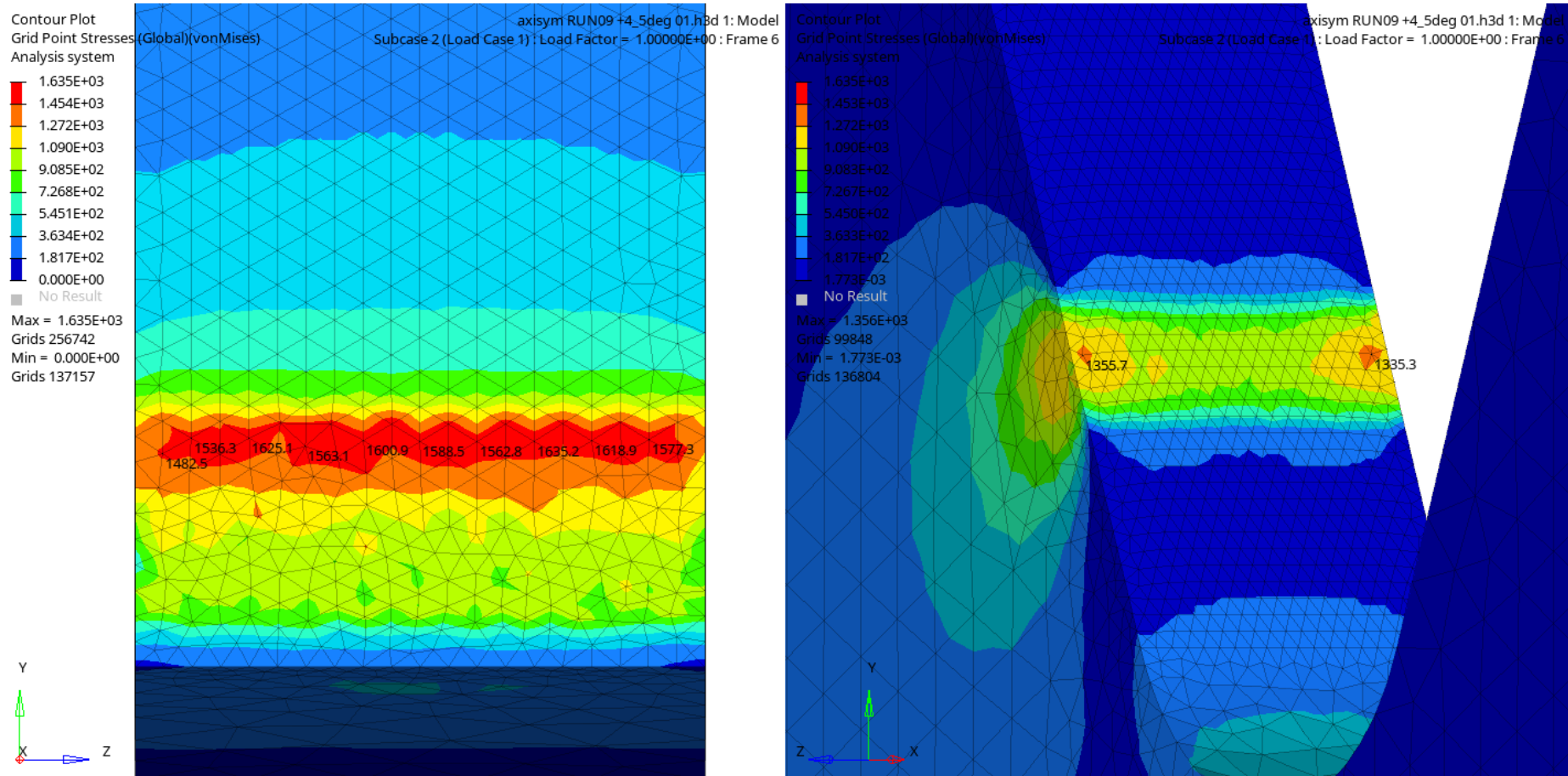
1.622E+03
1.298E+03
9.734E+02
6.489E+02
3.245E+02
0.000E+00
-3.270E+02
-6.541E+02
-9.811E+02
-1.308E+03
-1.635E+03
No Result

Max = 1.622E+03
Grids 256712
Min = -1.635E+03
Grids 256742

axisym RUN09 +4_5deg 01.h3d 1: Model
Subcase 2 (Load Case 1) : Load Factor = 1.00000E+00 : Frame 6

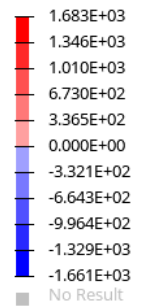


4.5 degrees rotation from tip contact



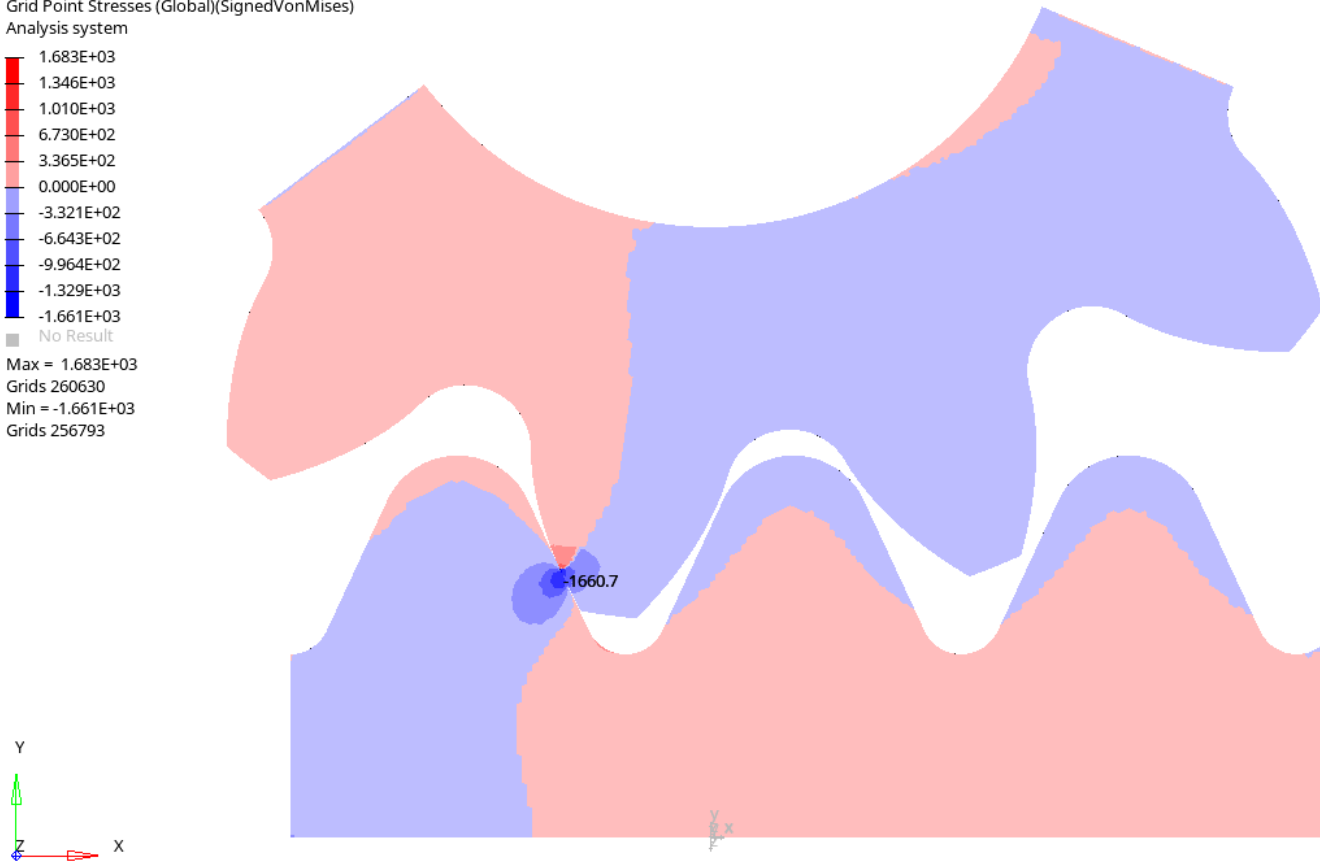
7.5 degrees rotation from tip contact

Contour Plot
Grid Point Stresses (Global)(SignedVonMises)
Analysis system

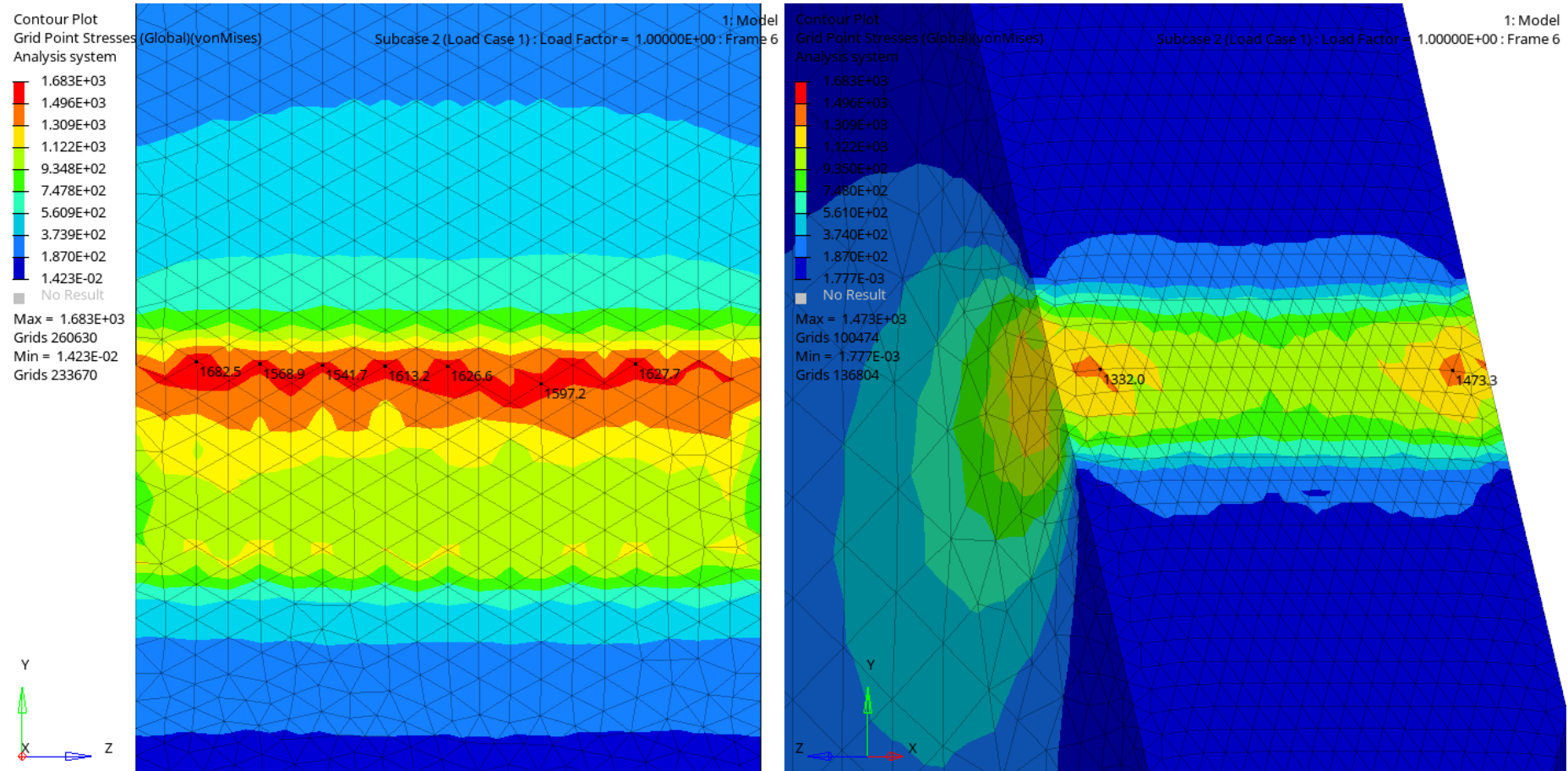


Max = 1.683E+03
Grids 260630
Min = -1.661E+03
Grids 256793

axisym RUN09 +7_5deg 01.h3d 1: Model
Subcase 2 (Load Case 1) : Load Factor = 1.00000E+00 : Frame 6

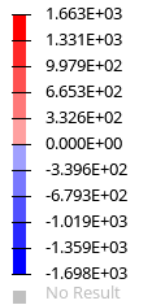


7.5 degrees rotation from tip contact



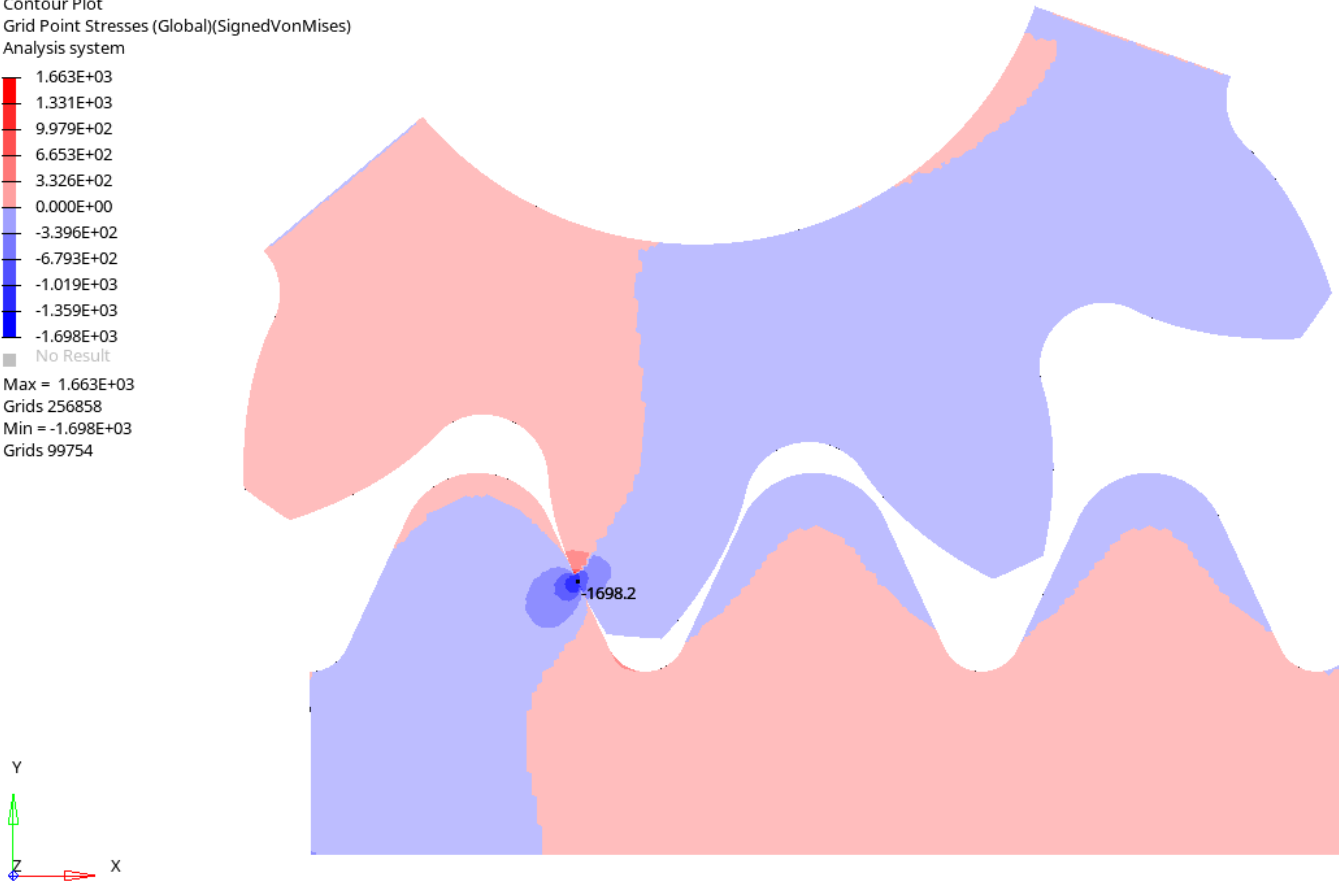
10.5 degrees rotation from tip contact

Contour Plot
Grid Point Stresses (Global)(SignedVonMises)
Analysis system

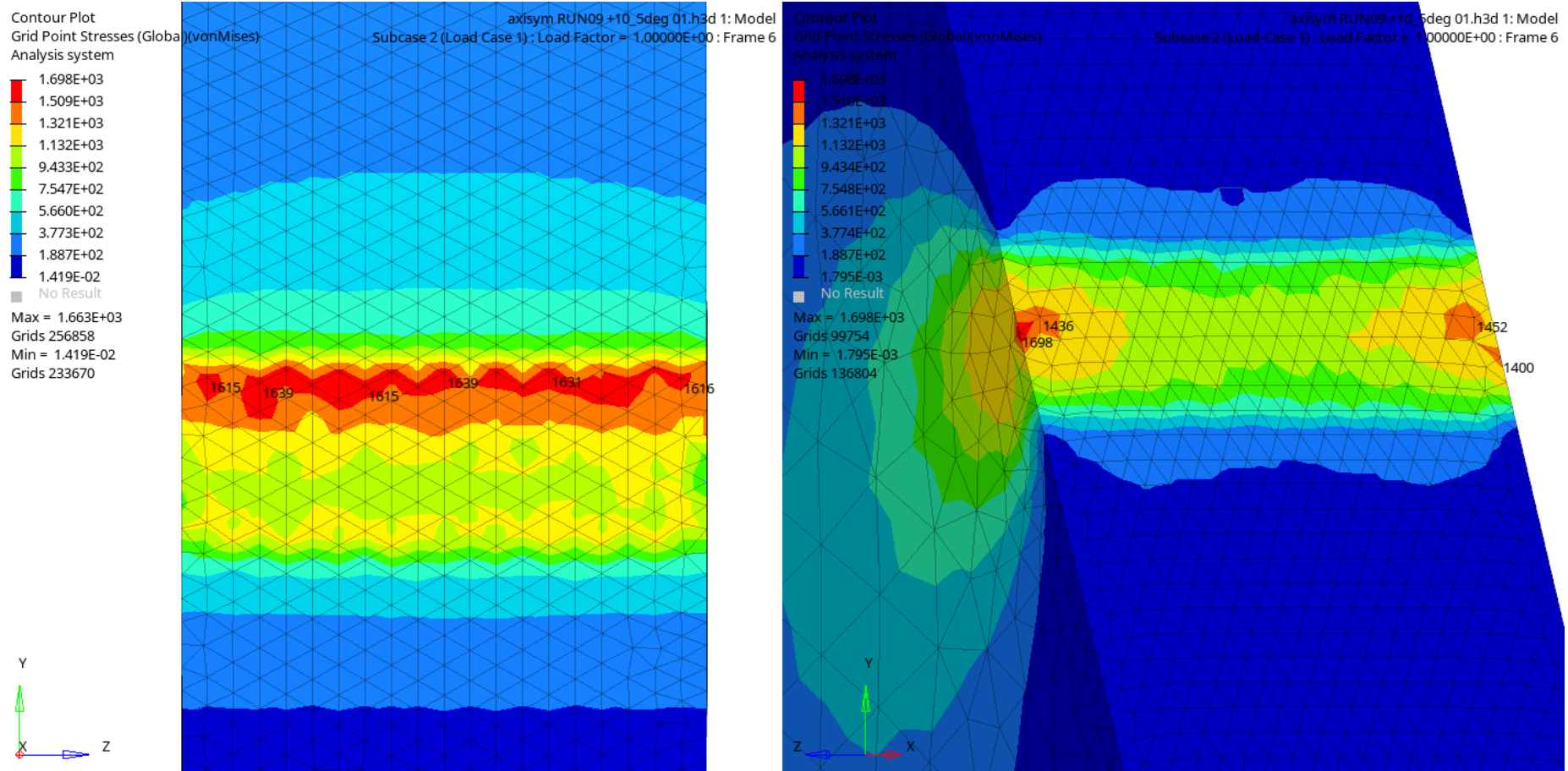


Max = 1.663E+03
Grids 256858
Min = -1.698E+03
Grids 99754

axisym RUN09 +10_5deg 01.h3d 1: Model
Subcase 2 (Load Case 1) : Load Factor = 1.00000E+00 : Frame 6

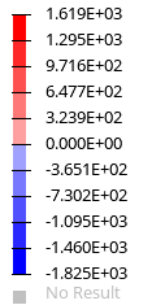


10.5 degrees rotation from tip contact



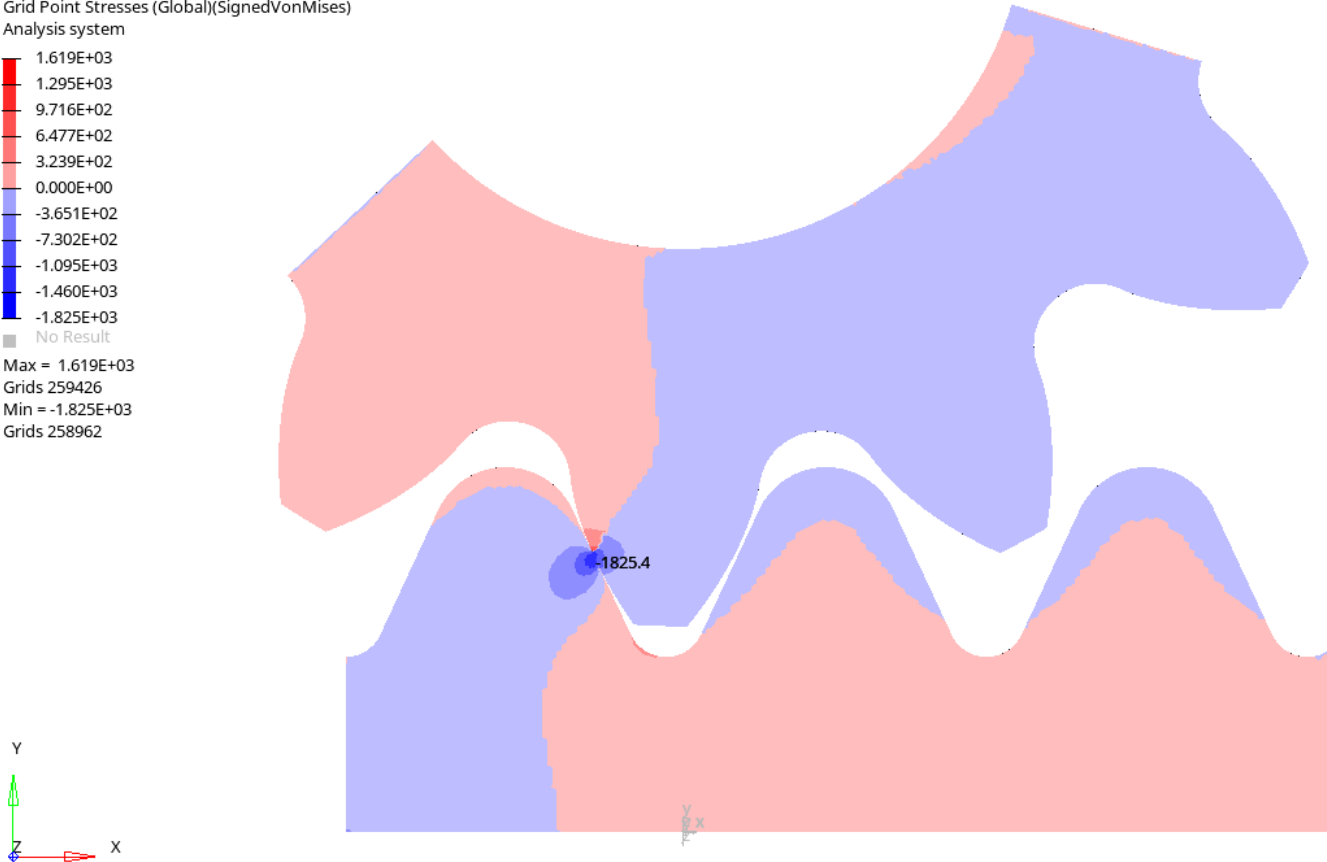
13.5 degrees rotation from tip contact

Contour Plot
Grid Point Stresses (Global)(SignedVonMises)
Analysis system

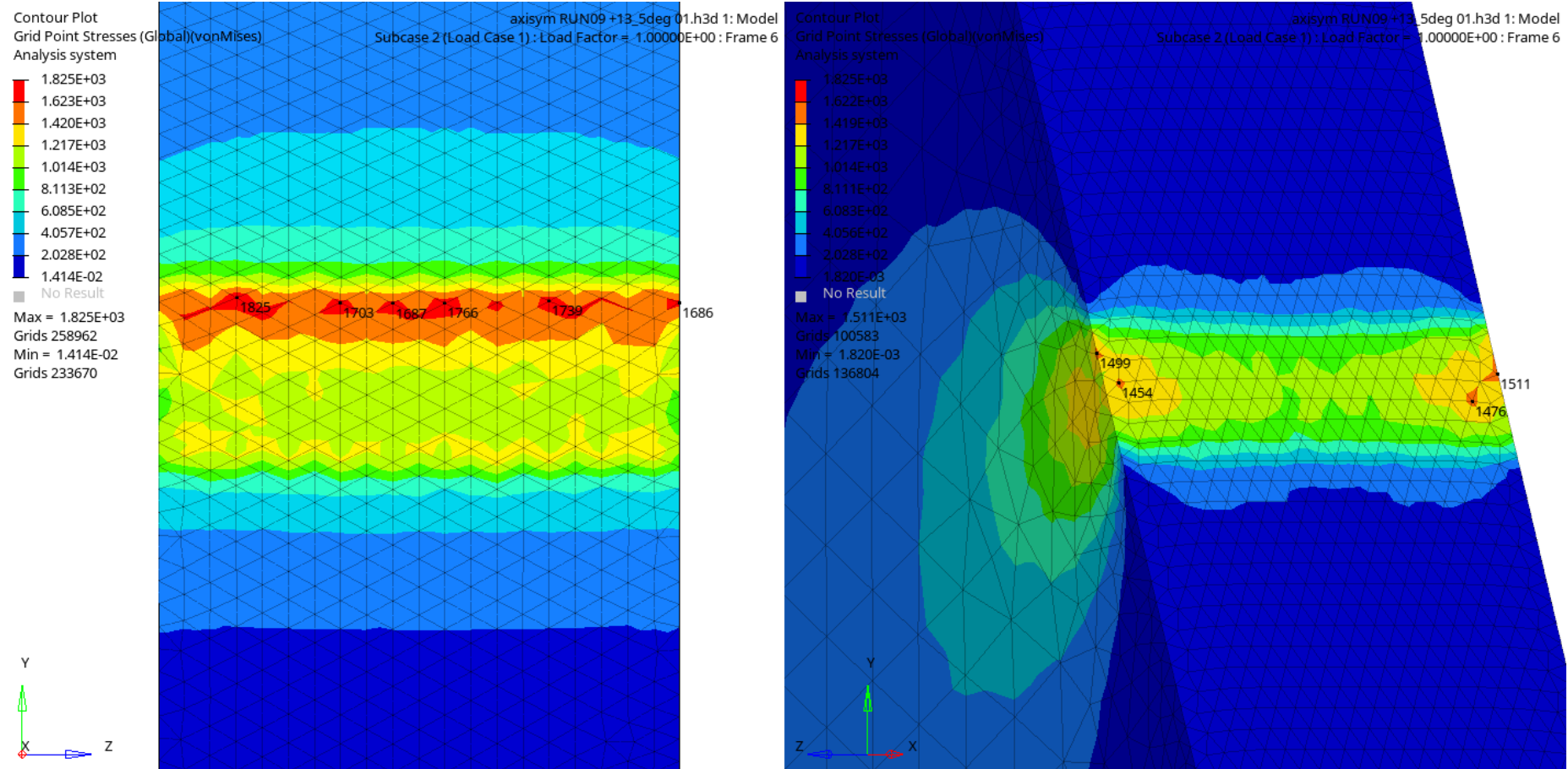


Max = 1.619E+03
Grids 259426
Min = -1.825E+03
Grids 258962

axisym RUN09 +13_5deg 01.h3d 1: Model
Subcase 2 (Load Case 1) : Load Factor = 1.00000E+00 : Frame 6

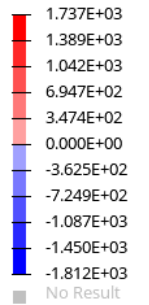


13.5 degrees rotation from tip contact



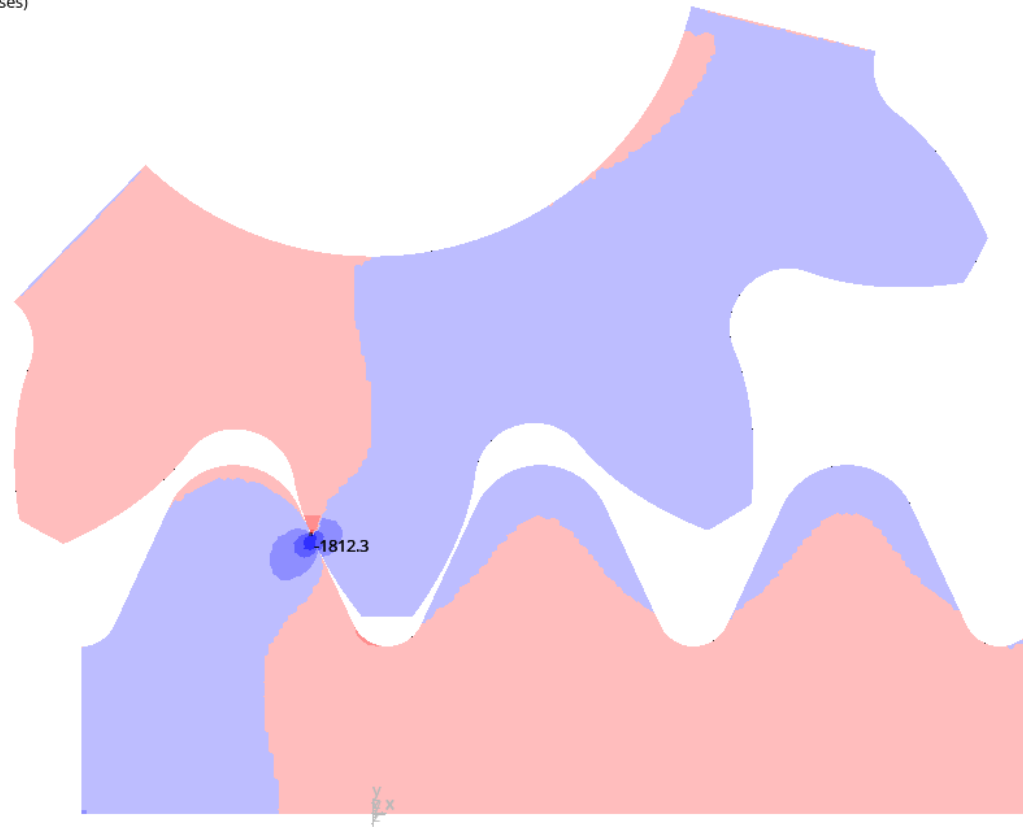
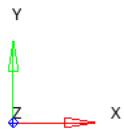
16.5 degrees rotation from tip contact

Contour Plot
Grid Point Stresses (Global)(SignedVonMises)
Analysis system

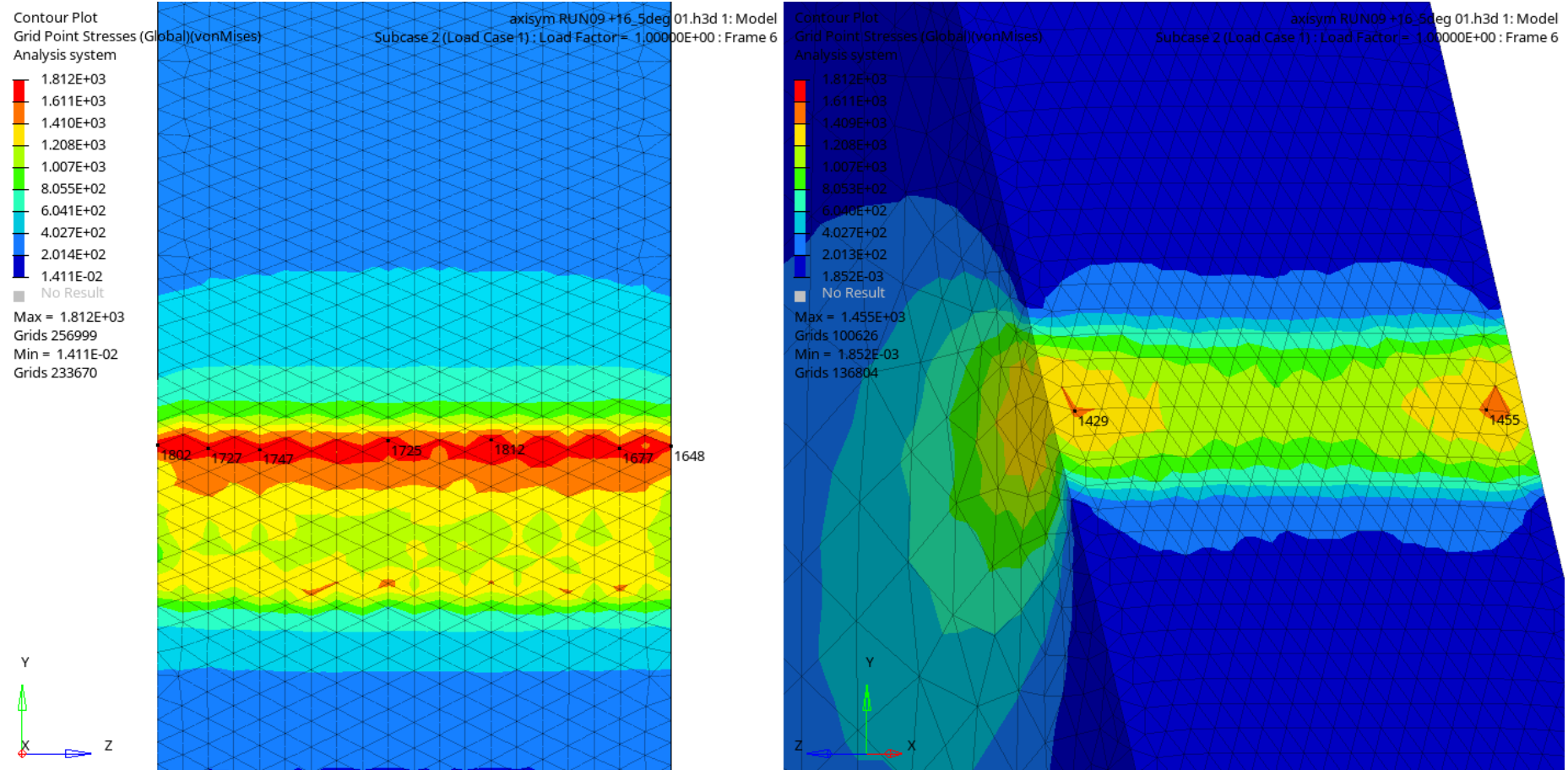


Max = 1.737E+03
Grids 258217
Min = -1.812E+03
Grids 256999

1: Model
Subcase 2 (Load Case 1) : Load Factor = 1.00000E+00 : Frame 6

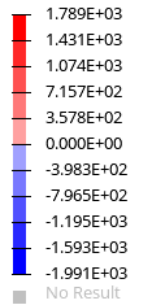


16.5 degrees rotation from tip contact



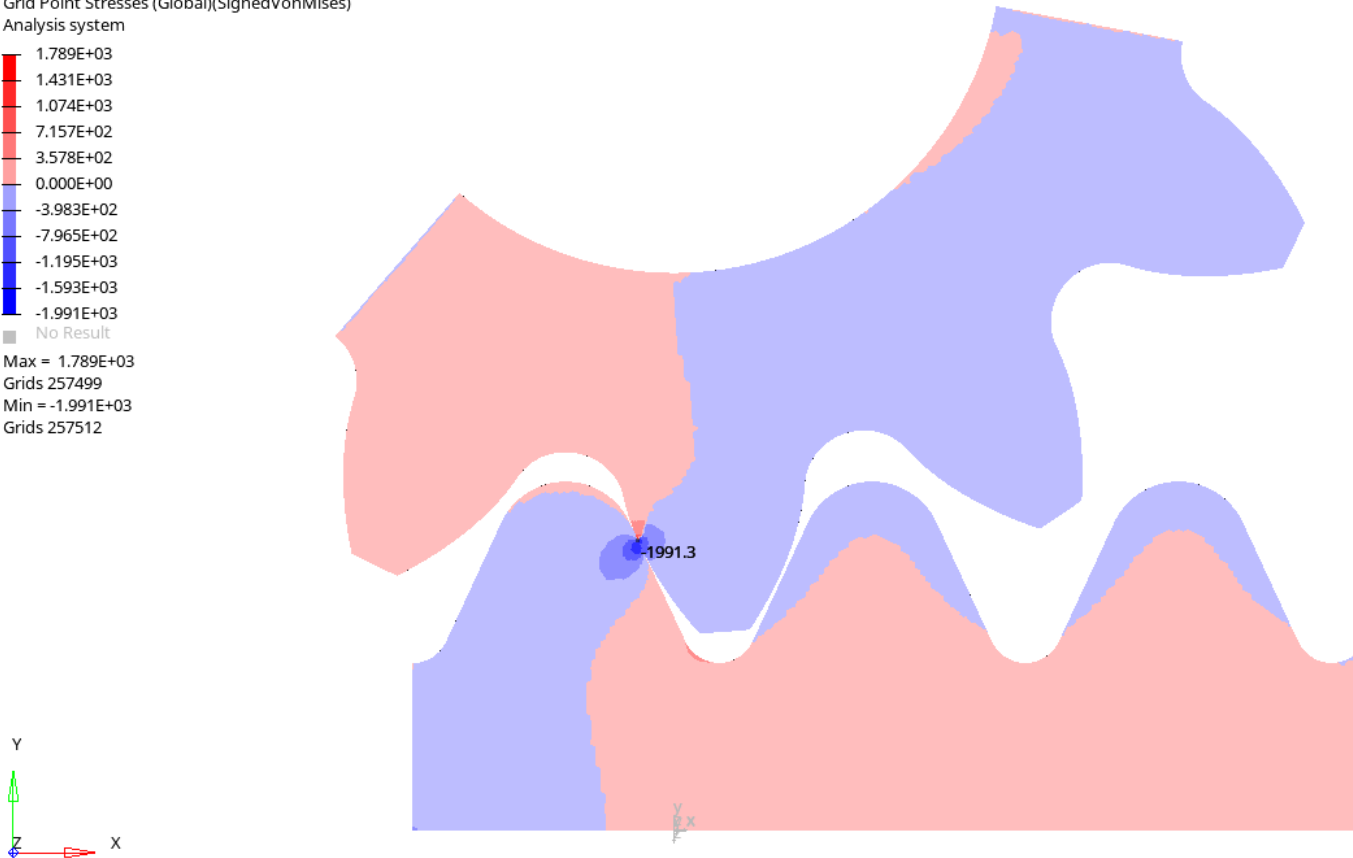
19.5 degrees rotation from tip contact

Contour Plot
Grid Point Stresses (Global)(SignedVonMises)
Analysis system

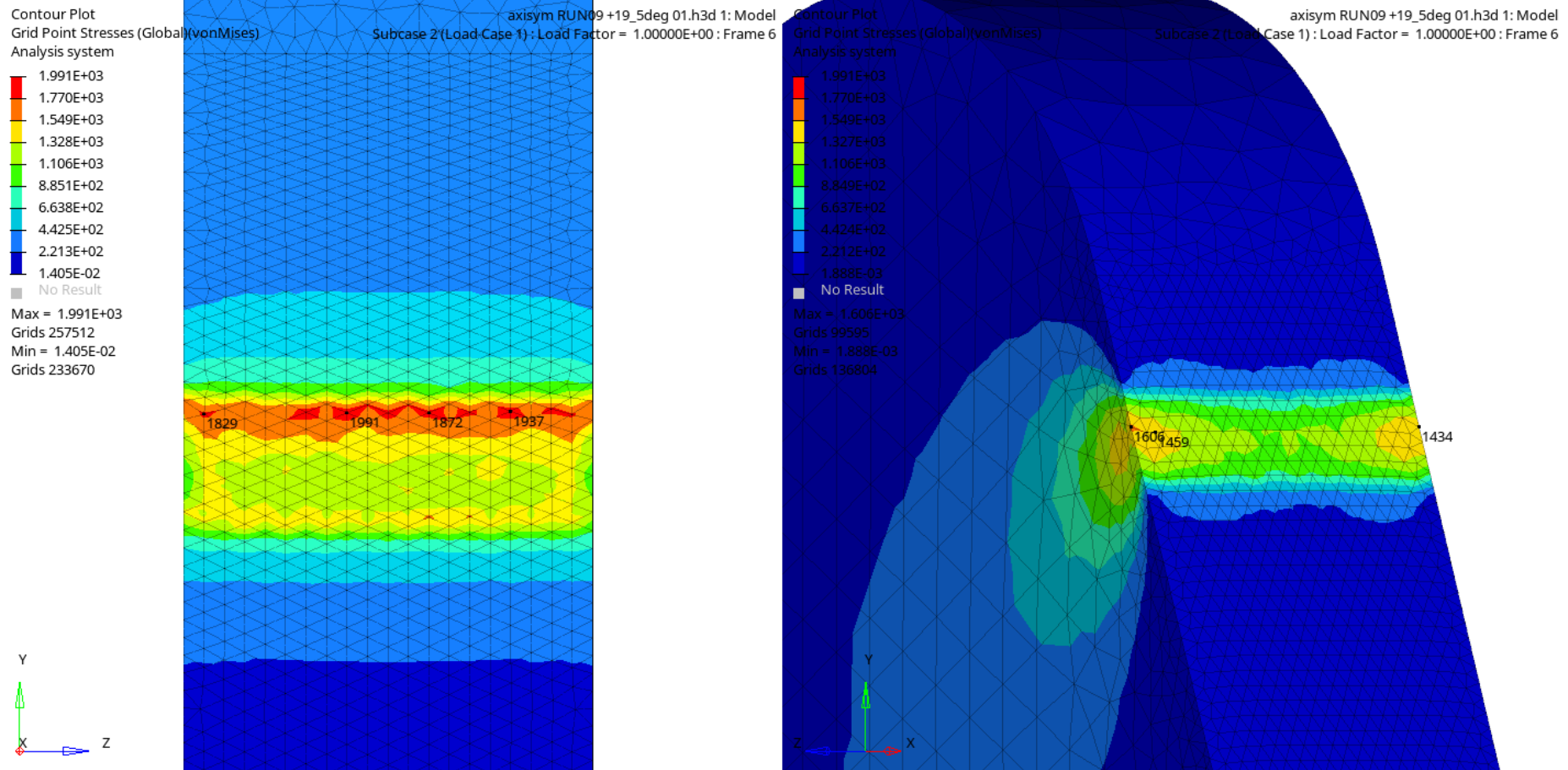


Max = 1.789E+03
Grids 257499
Min = -1.991E+03
Grids 257512

axisym RUN09 +19_5deg 01.h3d 1: Model
Subcase 2 (Load Case 1) : Load Factor = 1.00000E+00 : Frame 6

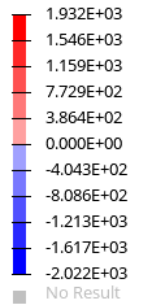


19.5 degrees rotation from tip contact



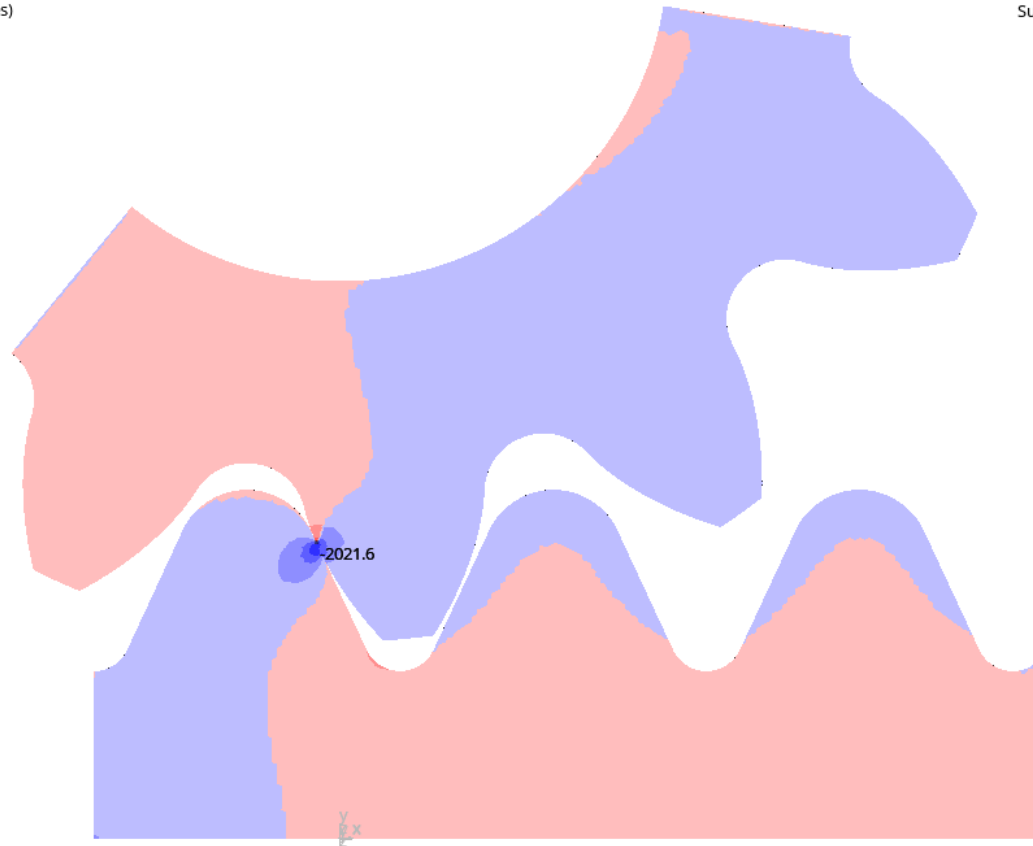
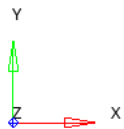
21 degrees rotation from tip contact

Contour Plot
Grid Point Stresses (Global)(SignedVonMises)
Analysis system



Max = 1.932E+03
Grids 256279
Min = -2.022E+03
Grids 257100

axisym RUN09 +21deg 01.h3d 1: Model
Subcase 2 (Load Case 1) : Load Factor = 2.00000E+00 : Frame 6



21 degrees rotation from tip contact

