

Autodesk Nastran Analysis Report

Date: 07/02/18
Author: Autodesk Customer
Subject: Analysis
Prepared For: Autodesk Customer
Software Used: Autodesk Nastran Version 12.1.0.925

Tables of Contents

[1. Summary](#)

[2. Assumptions](#)

[3. Model Definition](#)

[3.1 Group Definition](#)

[Table 3.1.1 Group Definition](#)

[Table 3.1.2 Part Mass Properties](#)

[3.2 Contact Definition](#)

[3.3 Material Properties](#)

[Table 3.3.1 Isotropic Material Definition](#)

[Table 3.3.2 Anisotropic Shell Element Material Definition](#)

[Table 3.3.3 Anisotropic Solid Element Material Definition](#)

[Table 3.3.4 Orthotropic Shell Element Material Definition](#)

[Table 3.3.5 Orthotropic Solid Element Material Definition](#)

[Table 3.3.6 Hyperelastic Element Material Definition](#)

[3.4 Mesh](#)

[Table 3.4.1 Element Initial Distortion Summary](#)

[4. Environment](#)

[4.1 Structural Loading](#)

[Table 4.1.1 Applied Load Vector Resultant](#)

[4.2 Structural Support](#)

[Table 4.2.1 Reaction Load Vector Resultant](#)

[5. Solution](#)

[Table 5.1.1 Displacement Summary](#)

[Table 5.1.2 Peak Displacement Component Summary](#)

[Table 5.1.3 Stress Results Summary](#)

[Table 5.1.4 Solution Error Measure and the Relative Stress Error Summary](#)

[6. Conclusion](#)

[7. Glossary](#)

1. Summary

The report documents design and analysis using Autodesk Nastran engineering simulation software. A linear static analysis was performed using the finite element model shown in the figure below. The model is divided into 3 property group(s). The units system is mm-N-s. The model consists of a total of 43047 nodes and 25995 elements.



Figure 1 - Finite Element Model

2. Assumptions

1. Displacements are small.
2. [Follower forces](#) are ignored.

3. Model Definition

3.1 Group Definition

The model is divided into 3 property group(s). Details for each group are given in Table 3.1.1.

1. The [bounding box](#) for all positioned bodies in the model measures 7,201 by 9,004 by 4,175mm along the basic coordinate system x, y and z axes, respectively.
2. The total mass of the model is 6,359E-06 t.
3. The model center of mass is located at (-22,22, -3,192, 8,011) mm.

Table 3.1.1 Group Definition

Property Group	Material	Bounding Box (mm)	Mass (t)	Volume (mm ³)	Nodes	Elements
SOLID 2	MAT 2	30,09, 18,68, 22,09	2,608E-06	2086,0	20793	12898
SOLID 3	MAT 2	39,58, 26,7, 20,72	3,286E-06	2629,0	20449	12396
SOLID 4	MAT 3	7,201, 9,004, 4,175	4,654E-07	58,17	941	701

Table 3.1.2 Part Mass Properties

Property Group	Material	Mass (t)	Center of Mass (mm)	Moments of Inertia (mm)
SOLID 2	MAT 2	2,608E-06	-34,85, -9,867, 1,952	9,355E-05, 1,649E-04, 1,569E-04
SOLID 3	MAT 2	3,286E-06	-11,72, 2,357, 12,98	1,422E-04, 2,962E-04, 3,293E-04
SOLID 4	MAT 3	4,654E-07	-25,49, -4,96, 6,904	2,467E-06, 1,176E-06, 3,081E-06

3.2 Contact Definition

The model contains 5 contact region(s).
- Adaptive stiffness scaling is enabled.

Table 3.2.1 Contact Definition

Name	Type	Contact Surface	Normal Stiffness	Penetration
Contact Region 6	General Contact	Surface 8, Surface 7	Stiffness Controlled	Unsymmetric
Contact Region 9	General Contact	Surface 11, Surface 10	Stiffness Controlled	Unsymmetric
Contact Region 12	General Contact	Surface 14, Surface 13	Stiffness Controlled	Unsymmetric
Contact Region 15	Bi-Directional Slide	Surface 17, Surface 16	Stiffness Controlled	Unsymmetric
Contact Region 18	Bi-Directional Slide	Surface 20, Surface 19	Stiffness Controlled	Symmetric

3.3 Material Properties

3.3.1 Isotropic Material Definition

Material ID	E	G	NU	RHO	ALPHA	T-REF
2	2346,0	862,7	0,36	1,25E-09	0,0	0,0
3	1,93E+05	7,423E+04	0,3	8,E-09	1,E-05	0,0

3.3.2 Anisotropic Shell Element Material Definition

No Data

3.3.3 Anisotropic Solid Element Material Definition

No Data

3.3.4 Orthotropic Shell Element Material Definition

No Data

3.3.5 Orthotropic Solid Element Material Definition

No Data

3.3.6 Hyperelastic Element Material Definition

No Data

3.4 Mesh

The finite element mesh is shown in the figure below. The model consists of a total of 43047 nodes and 25995 elements.

Table 3.4.1 Element Initial Distortion Summary

Property Group	Property Type	Aspect Ratio	Recommended Limit	Taper Ratio	Recommended Limit	Skew Angle	Recommended Limit	Warping Angle	Recommended Limit
SOLID 2	TET	11,49	100,0	0,0	0,0	137,6	80,0	0,0	0,0
SOLID 3	TET	3,853	100,0	0,0	0,0	135,0	80,0	0,0	0,0
SOLID 4	TET	4,46	100,0	0,0	0,0	134,1	80,0	0,0	0,0

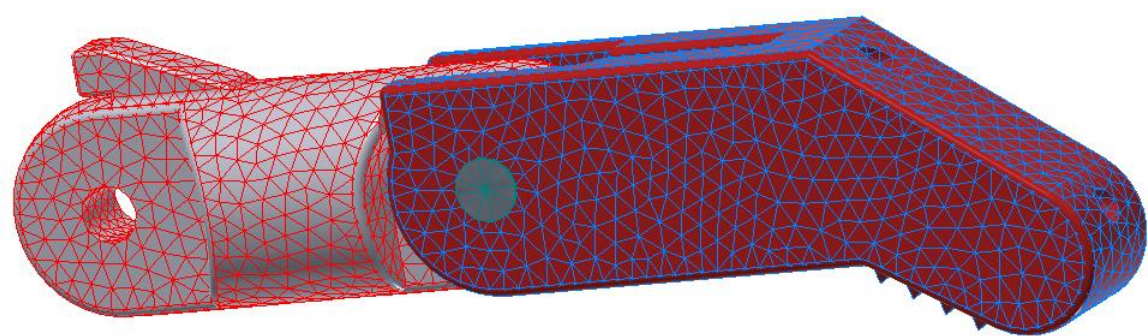


Figure 2 - Finite Element Mesh

4. Environment

4.1 Structural Loading

The finite element environments are shown in the figures below. Applied structural loading is summarized in Table 4.1.1. Applied load vector resultants are defined in the basic coordinate system. Moments are summed about location (0.0,0.0,0.0).

Table 4.1.1 Applied Load Vector Resultant

Subcase	Resultant Force(N)			Resultant Moment(N mm)		
	XT	YT	ZT	XR	YR	ZR
SUBCASE 1	0,9871	-0,3738	9,943	78,79	41,71	-6,254

4.2 Structural Support

Reaction loads are summarized in Table 4.2.1. Reaction load vector resultants are defined in the basic coordinate system. Moments are summed about location (0.0,0.0,0.0).

Table 4.2.1 Reaction Load Vector Resultant

Subcase	Resultant Force (N)			Resultant Moment(N mm)		
	XT	YT	ZT	XR	YR	ZR
SUBCASE 1	16,22	7,865	17,16	-219,5	694,6	-109,2



Figure 3 - Applied Load



VECTOR PLOT: SPC FORCE; COMPONENTS: MAGNITUDE
OUTPUT SET: SUBCASE 1

Figure 4 - Reaction Load

5. Solution

The solution to the Environment defined in Section 4 applied to the Model defined in Section 3 is given below. The program selected the PCGLSS linear solver. Total solution time was 4493.4 seconds. The largest [solution error measure](#) was 3,677E-08 for SUBCASE 1. The largest solid element [relative stress error](#) was 8,128E-02 for SUBCASE 1. The results are summarized in the table(s) and figure(s) below.

Table 5.1.1 Displacement Summary

Subcase	Minimum Displacement (mm)	Property Group	Maximum Displacement (mm)	Property Group
Subcase 1	1,281E-03	Pasador:1	9,267E-03	Pasador:1
Subcase 1	6,081E-03	Falange2:1	0,3248	Falange2:1
Subcase 1	0,0	Falange1ª:1	1,599E-02	Falange1ª:1
Subcase 1	0,0		0,3248	

Table 5.1.2 Peak Displacement Component Summary

Subcase	Displacement Components (mm)			Rotation Components (mm)		
	XT	YT	ZT	XR	YR	ZR
SUBCASE 1	0,1062	6,22E-02	0,3179	0,0	0,0	0,0

Table 5.1.3 Stress Results Summary

Subcase	Minimum Principal Stress (MPa)	Property Group	Maximum Principal Stress (MPa)	Property Group	Maximum Von Mises Stress (MPa)	Property Group
Subcase 1	-6,633E-05	Pasador:1	6,343E-05	Pasador:1	6,87E-05	Pasador:1
Subcase 1	-36,11	Falange2:1	10,61	Falange2:1	24,19	Falange2:1
Subcase 1	-18,04	Falange1ª:1	7,36	Falange1ª:1	13,98	Falange1ª:1
Subcase 1	-36,11		10,61		24,19	

Table 5.1.4 [Solution Error Measure](#) and the [Relative Stress Error](#) Summary

Subcase	Solution Error Measure	Shell Element Relative Stress Error	Solid Element Relative Stress Error
SUBCASE 1	3,677E-08	n/a	8,128E-02

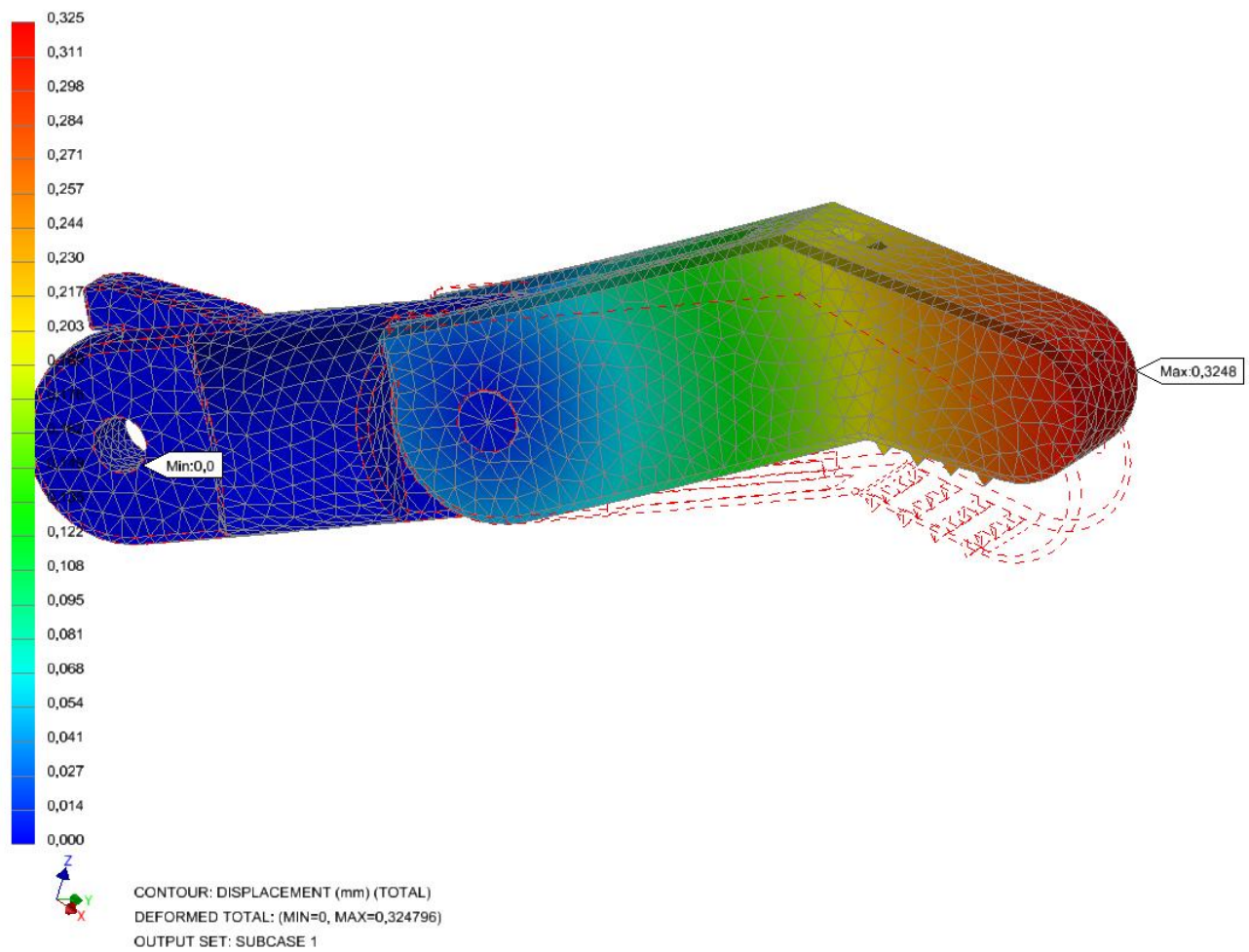


Figure 5 - OUTPUT SET: SUBCASE 1 -- DEFORMED TOTAL: (MIN=0, MAX=0,324796) -- CONTOUR: DISPLACEMENT (mm) (TOTAL)

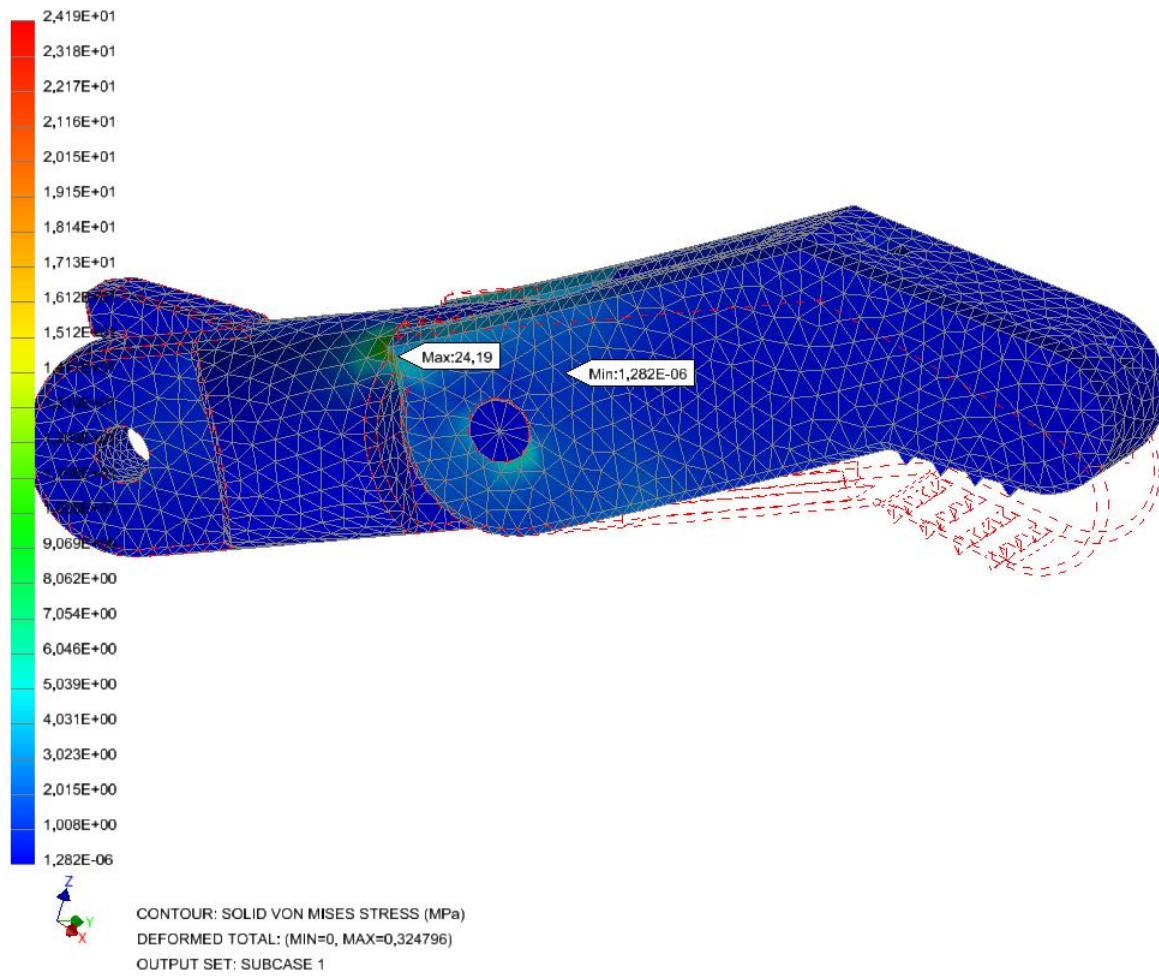


Figure 6 - OUTPUT SET: SUBCASE 1 -- DEFORMED TOTAL: (MIN=0, MAX=0,324796) -- CONTOUR: SOLID VON MISES STRESS (MPa)

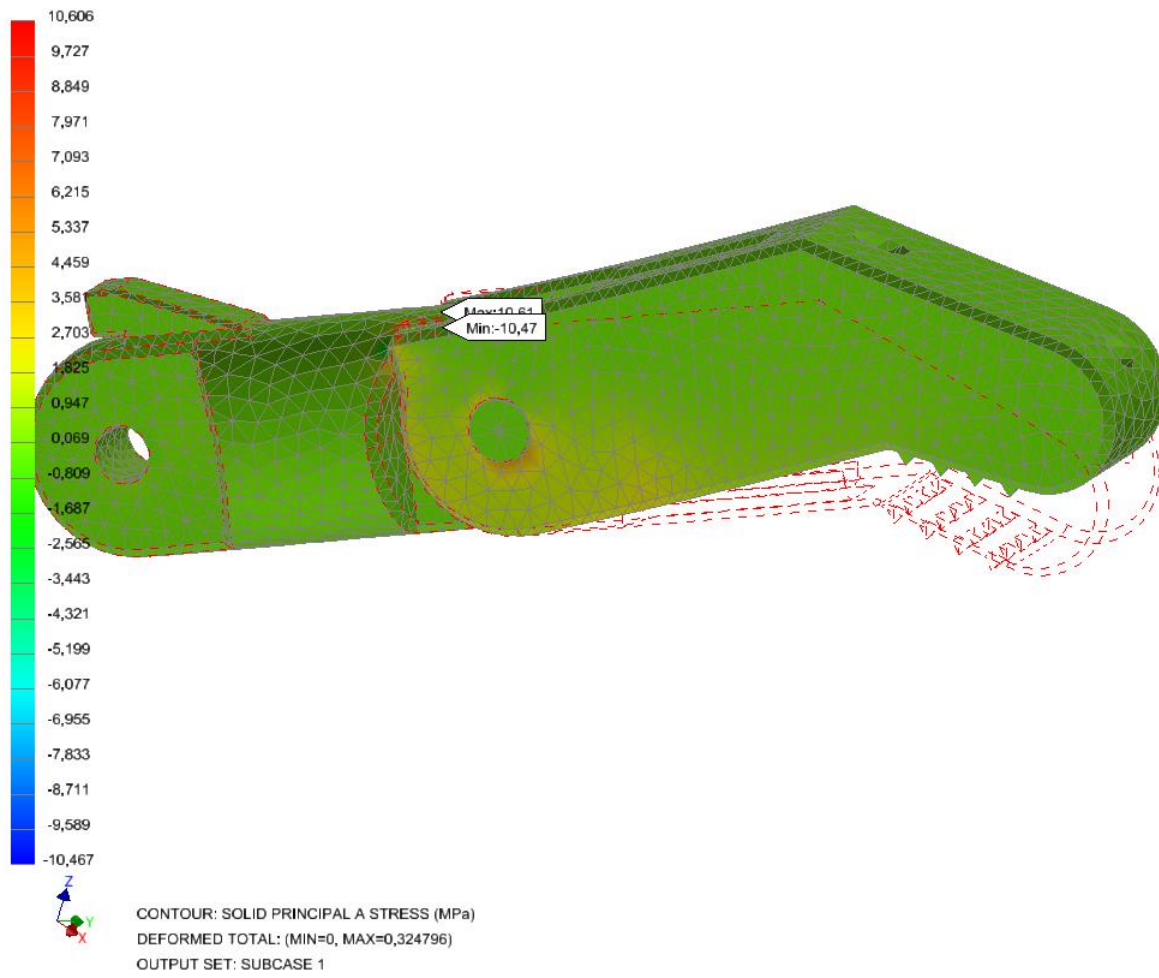


Figure 7 - OUTPUT SET: SUBCASE 1 -- DEFORMED TOTAL: (MIN=0, MAX=0,324796) -- CONTOUR: SOLID PRINCIPAL A STRESS (MPa)

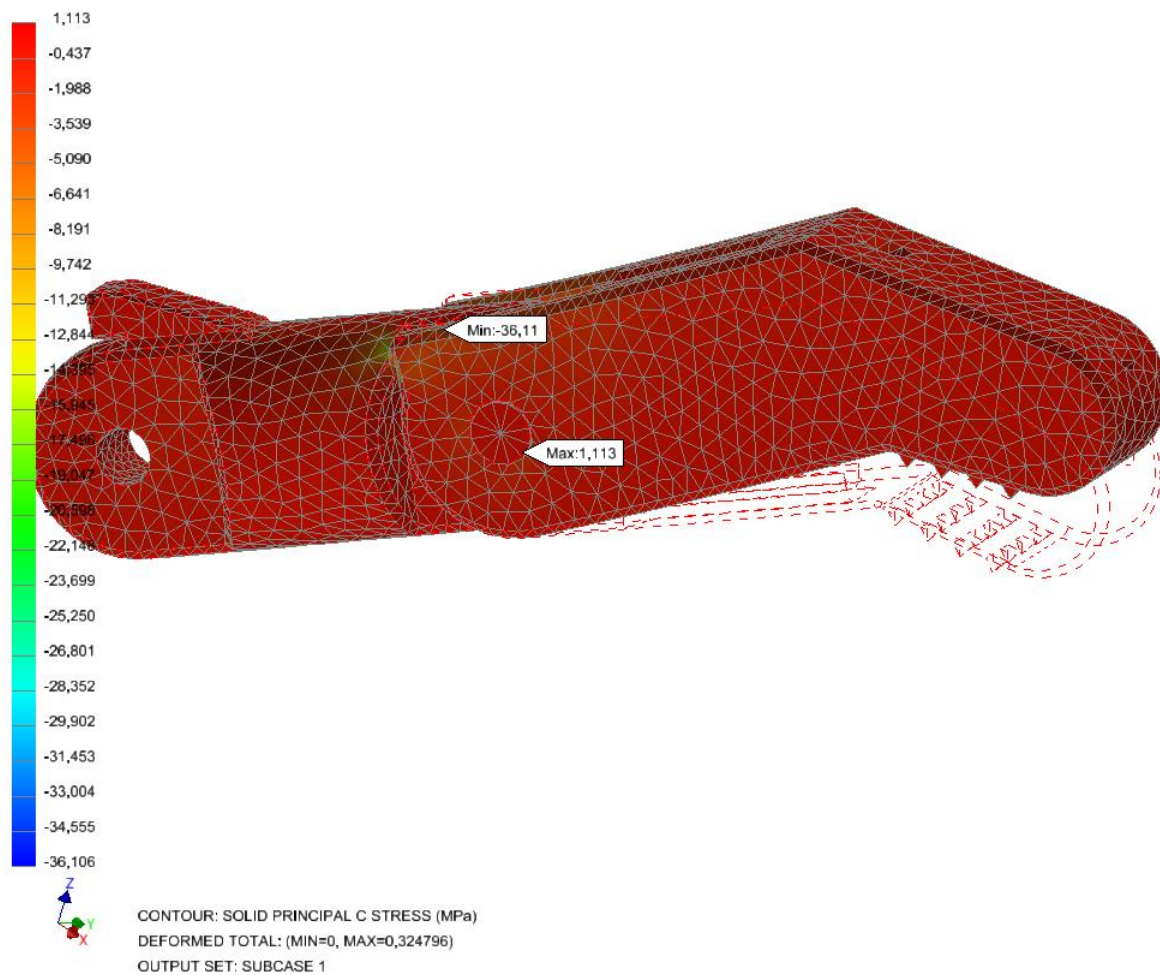


Figure 8 - OUTPUT SET: SUBCASE 1 -- DEFORMED TOTAL: (MIN=0, MAX=0,324796) -- CONTOUR: SOLID PRINCIPAL C STRESS (MPa)

6. Conclusion:

A linear static analysis was performed using the Autodesk Nastran Version 12.1.0.925 finite element solver on the Izlld9fdc structure. The finite element model contained mainly Falange1^a:1 elements and consisted of 132735 degrees of freedom.1 loading condition was analyzed.The maximum displacement was 9,267E-03 mm (load case Subcase 1)The maximum von Mises stress was 6,87E-05 (load case Subcase 1).

7. Glossary:

Aspect Ratio

Ratio of an element's longest side to its adjacent side.

Bi-Directional Slide

Prevents contacting regions from separating or closing but permits sliding (zero coefficient of friction)

Bounding Box

A three-dimensional cube aligned to the global x,y and z axes that exactly contains a body or assembly.

Follower Force

Loads that follow the motion of the structure as it deforms.

General Contact

Models standard nonlinear surface contact with friction if specified.

Relative Stress Error

A measure of mesh convergence (values greater than 0.01 may indicate that further mesh refinement is required in areas with large stress gradients over a few elements).

Rough Contact

Nonlinear contact that allows separation and closure but does not permit sliding (infinite friction).

Skew Angle

The angle between the lines that join opposite midsides of a quadrilateral face.

Solution Error Measure

A measure of solution quality (values less than 1.0E-07 are generally considered acceptable).

Taper Ratio

The ratio of the areas on the two sides of a diagonal of a quadrilateral face.

Warping Angle

The extent to which a quadrilateral face deviates from being planar.

Welded Contact

Prevents contacting regions from sliding, separating, or closing.