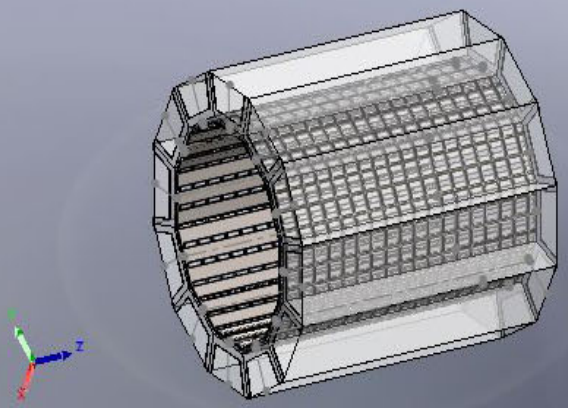
Em_Cal_Barrel_Support

Static strength analysis for optimal design and material

By: Avishay Mizrahi



Agenda

Goals:

The basic hypotheses for analysis:

- Shape
- Material

Mesh designs

Results/Tradeoff

Goals

Choosing a concept for mesh design

Parameter for success: 1mm max Deflection.

Constraints:

- Paramagnetic material.
- 19mm max thickness for each beam.

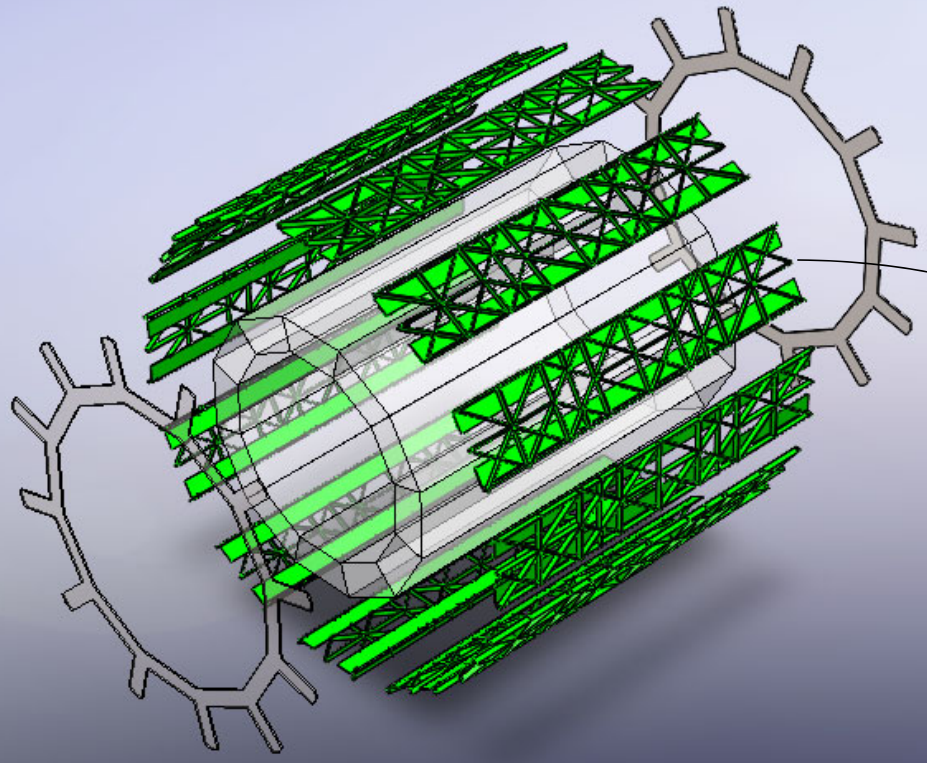
Nice to have:

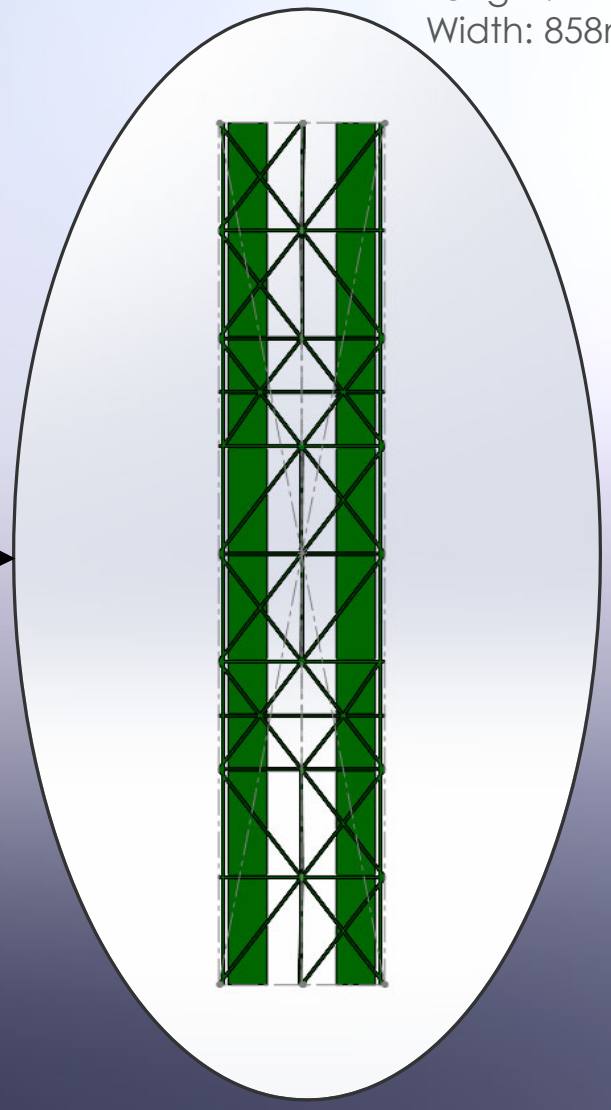
- Lightweight
- Symmetric shape (easier to manufacture)

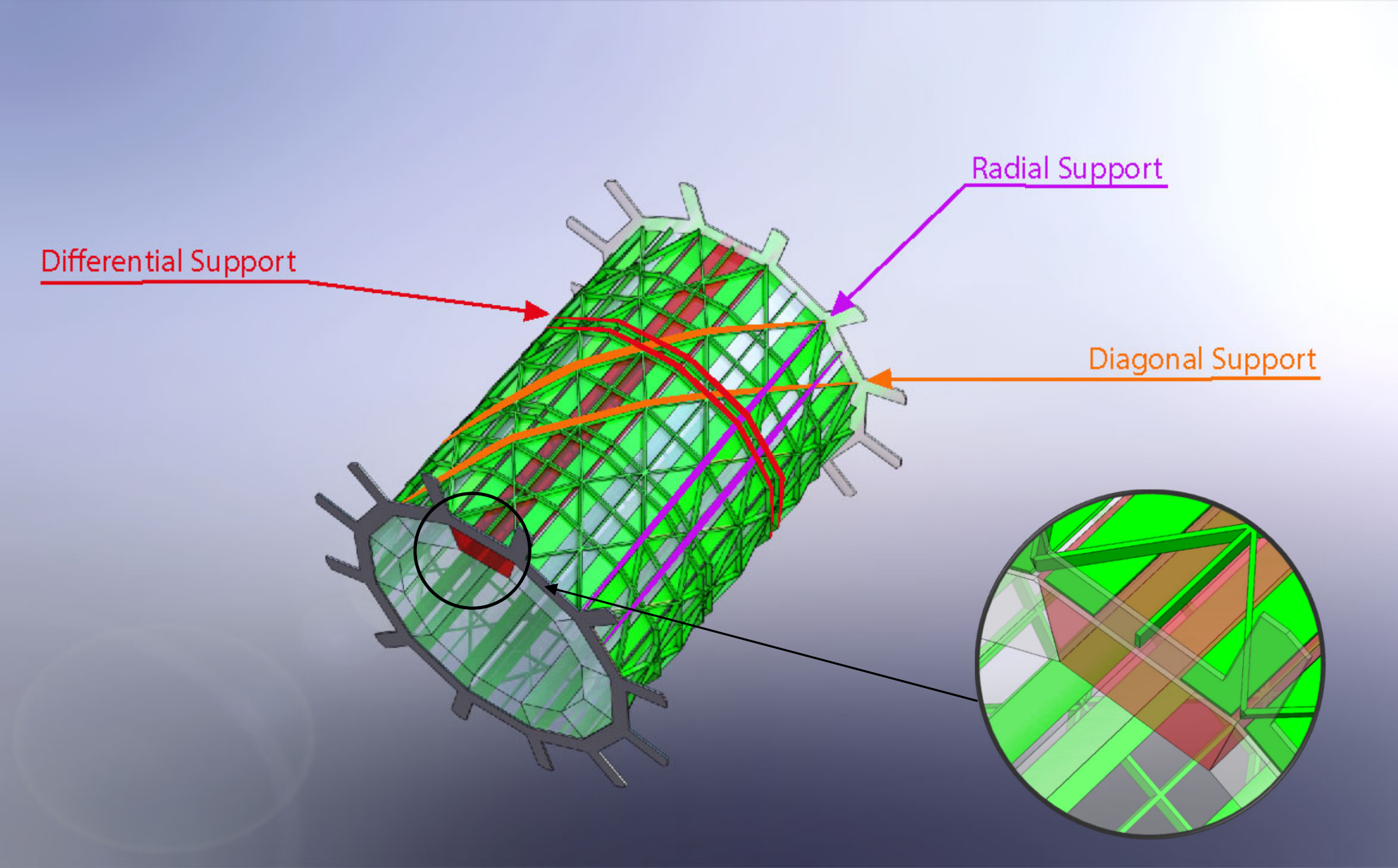
Solver: Solidworks simulation.

Main structure

Thickness: 76.2 mm
Length: 4446.35 mm
Width: 858mm






Radial Support
Differential Support
Diagonal Support

Material groups- Focusing on metals

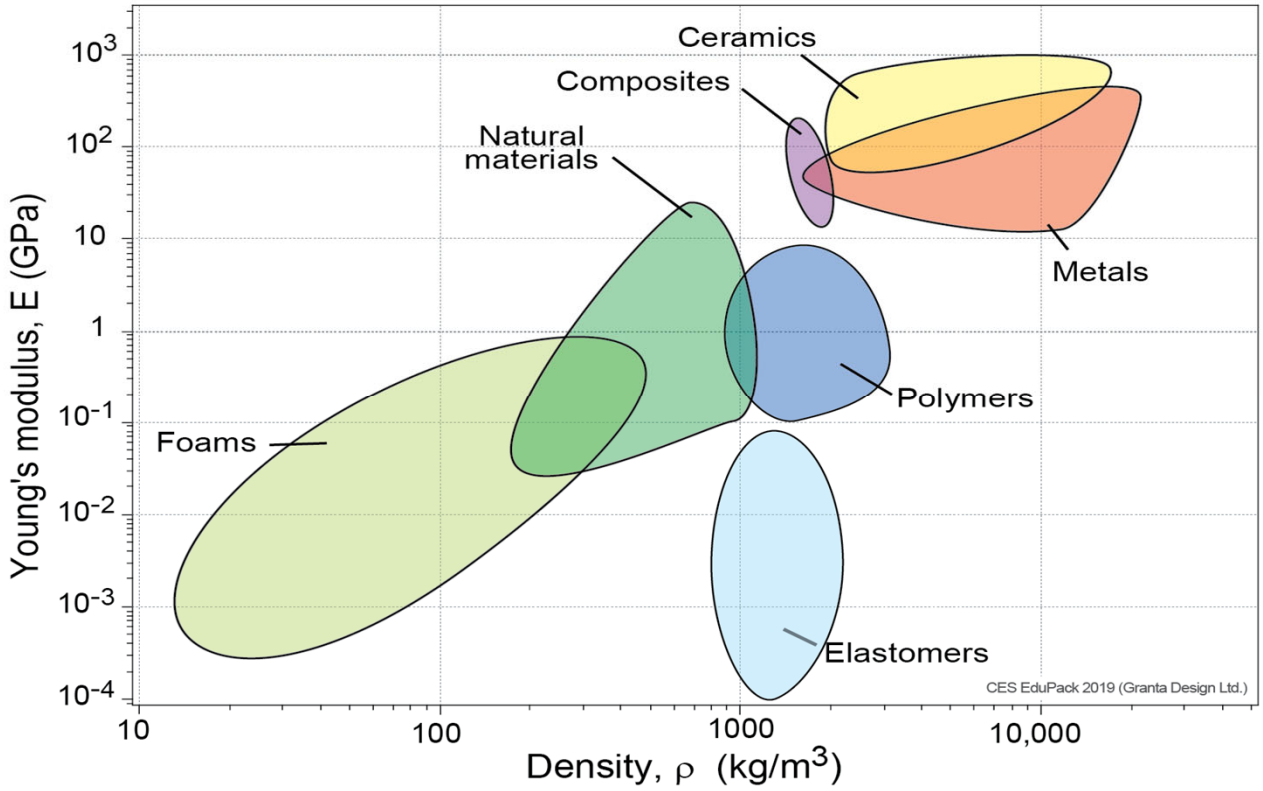
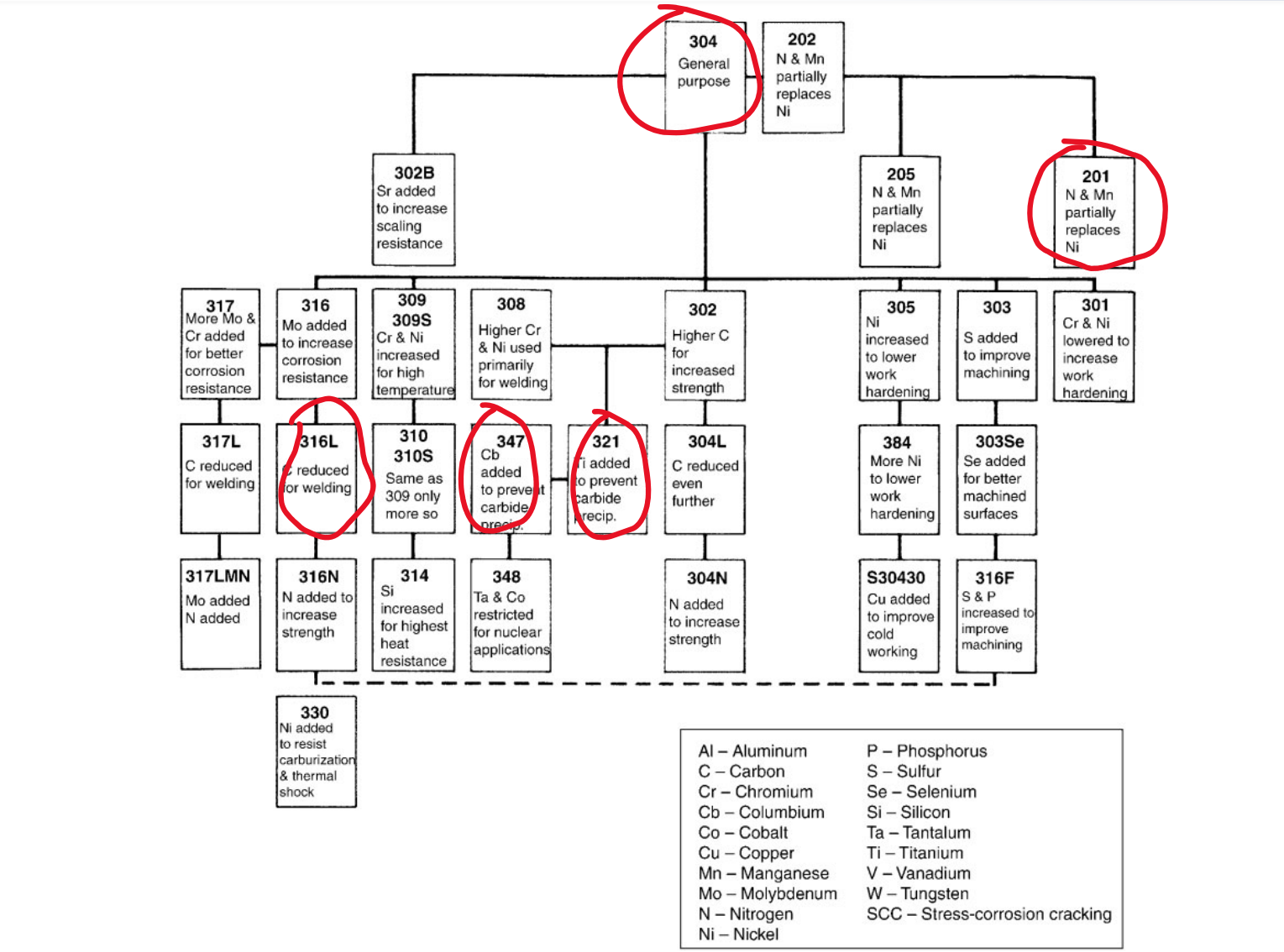


Chart created using CES EduPack 2019,ANSYS Granta © 2020 Granta Design

Austenitic Stainless Steels meet our criteria



do not magnetize

Materials list tested on each mesh

- Aluminum 6061-T6 (SS)
- Aluminum 7075-T6 (SN)
- Al 7050-T7651
- Al 7050-T73510

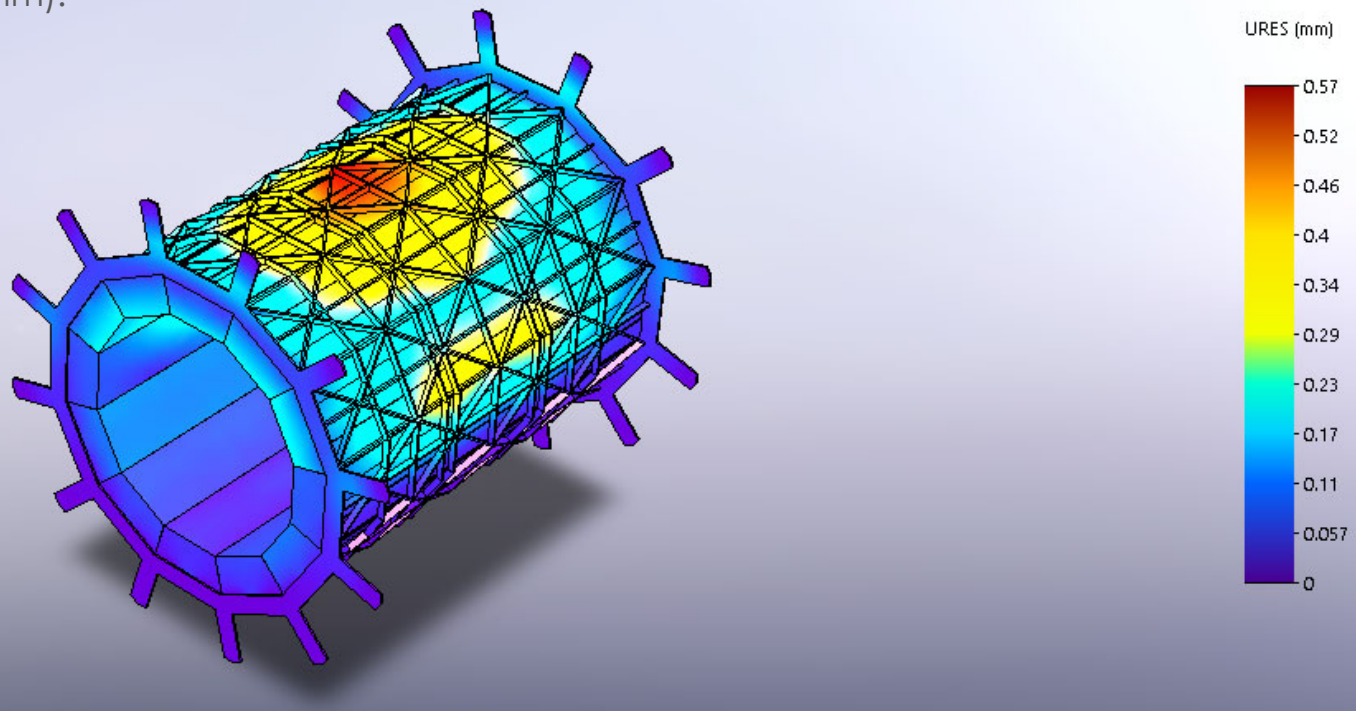
- Ti-6Al-2Sn-2Zr-2Mo-2Cr-0.25Si (SS)
- Titanium Ti-8Al-1Mo-1V
- Ti-3Al-8V-6Cr-4Mo-4Zr (SS)

- 201 Annealed Stainless Steel (SS)
- AISI 304
- AISI 321 Annealed Stainless Steel (SS)
- AISI 347 Annealed Stainless Steel (SS)
- AISI 316 Annealed Stainless-Steel Bar (SS)

may develop magnetic response when cold worked

Mesh 1

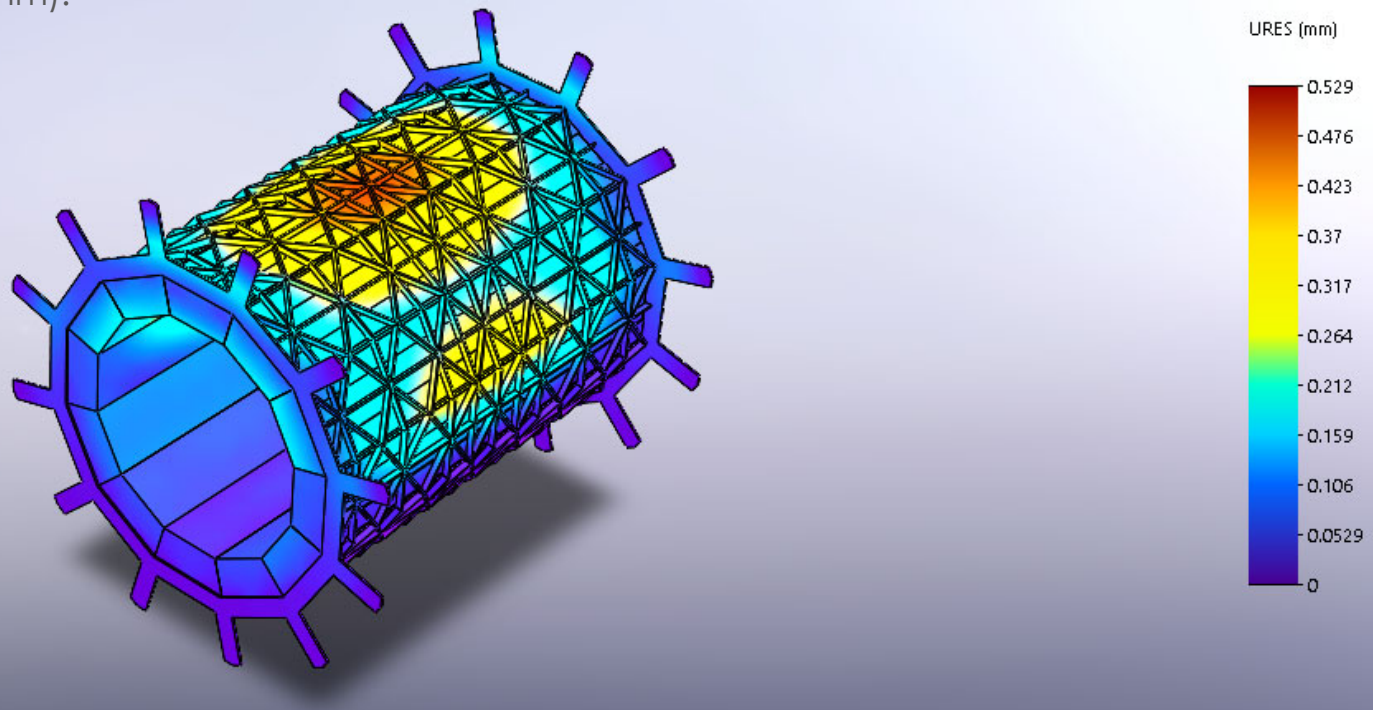
- Beams Volume: 0.599 m³.
- Works with Titanium and Stainless-Steel alloys.
- Uniform width to all beams (19mm).



*Isometric

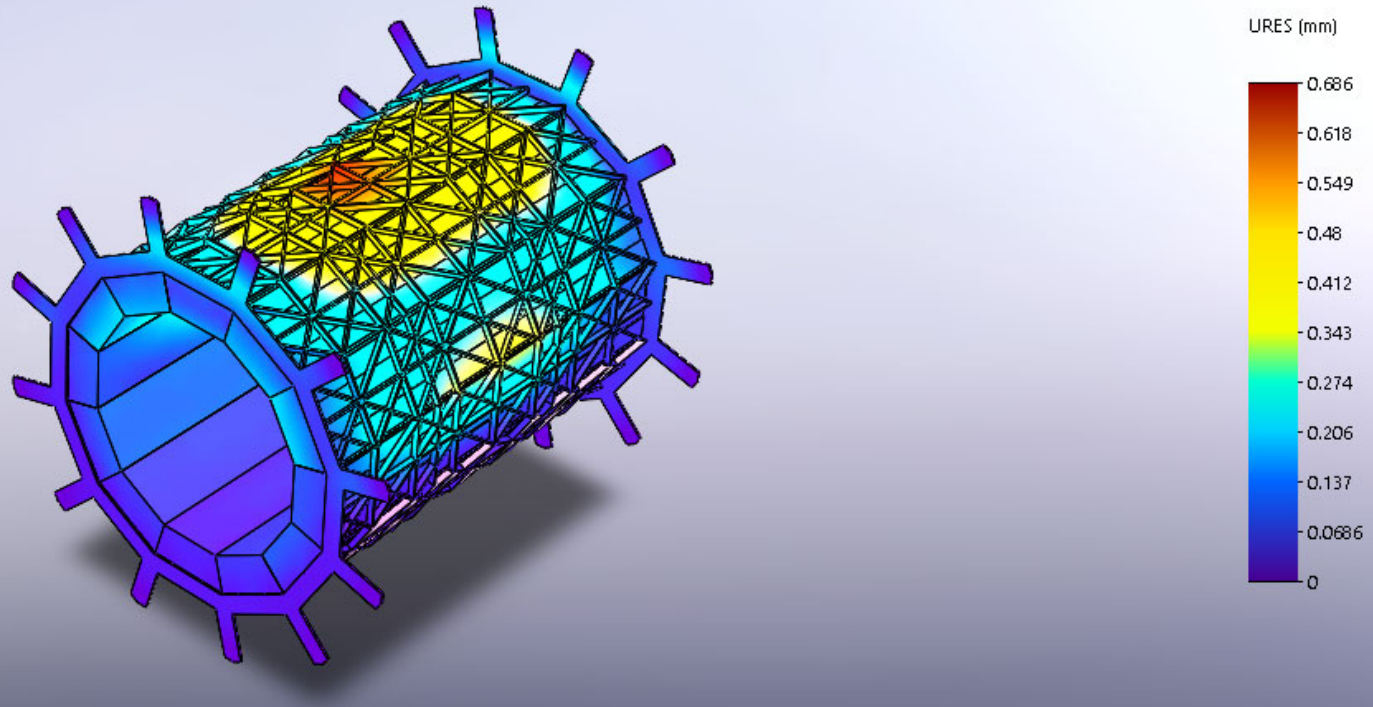
Mesh 2

- Beams Volume: 0.65 m³.
- Works with Titanium and Stainless-Steel alloys.
- Uniform width to all beams (19mm).



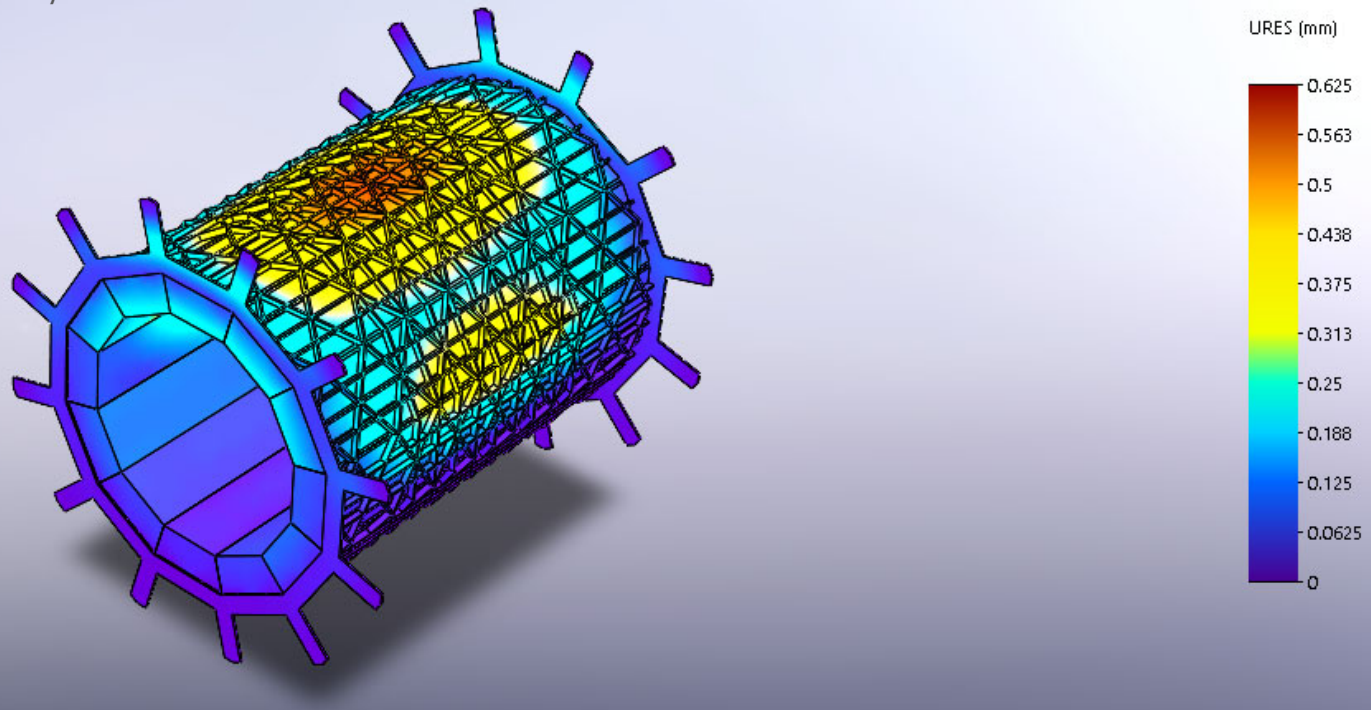
Mesh 3

- Volume: 0.674 m³
- Works with 2 types of Titanium alloys and Stainless-Steel alloys.
- Uniform width to all beams (19mm).



Mesh 4

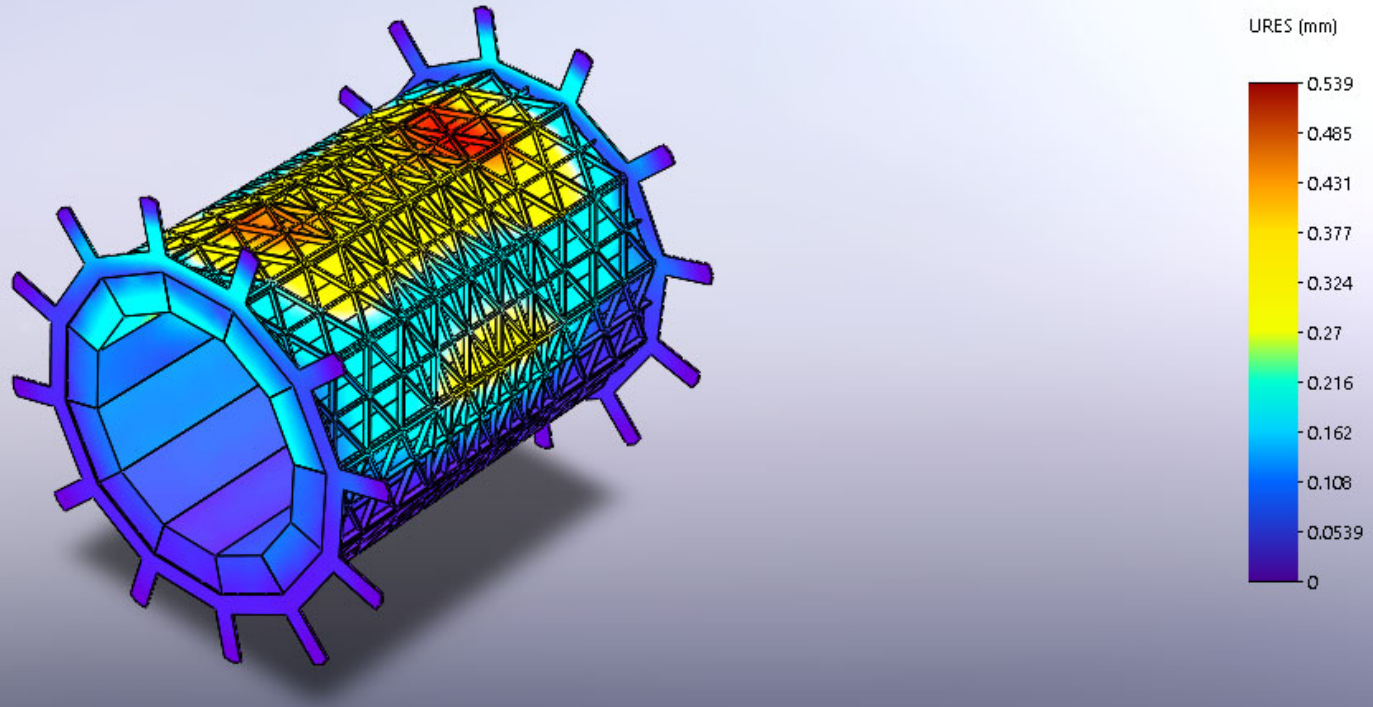
- Volume: 0.782 m³
- Works with 2 types of Titanium alloys and Stainless-Steel alloys.
- Uniform width to all beams (19mm).



*Isometric

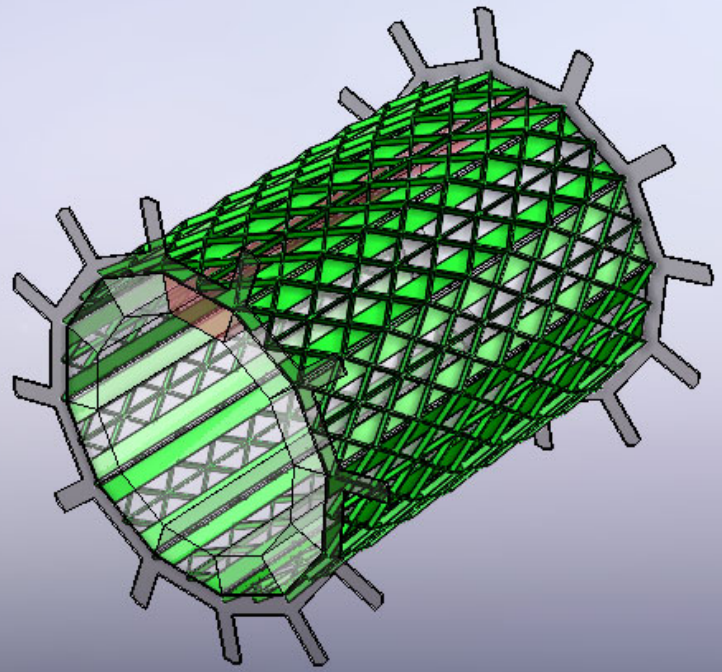
Mesh 5

- Volume: 0.82m³
- Works with Titanium and Stainless-Steel alloys.
- Uniform width to all beams (19mm).



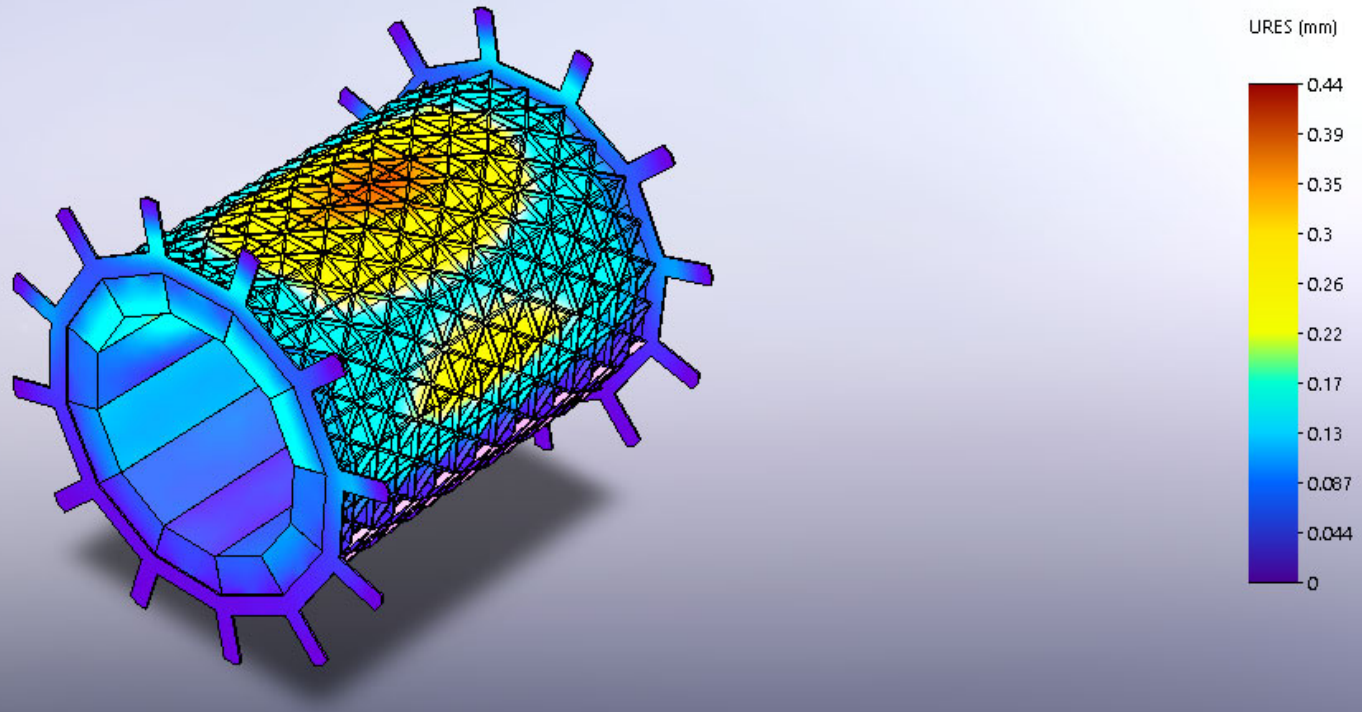
Mesh 6

- Did not pass the 1 mm deflection test.



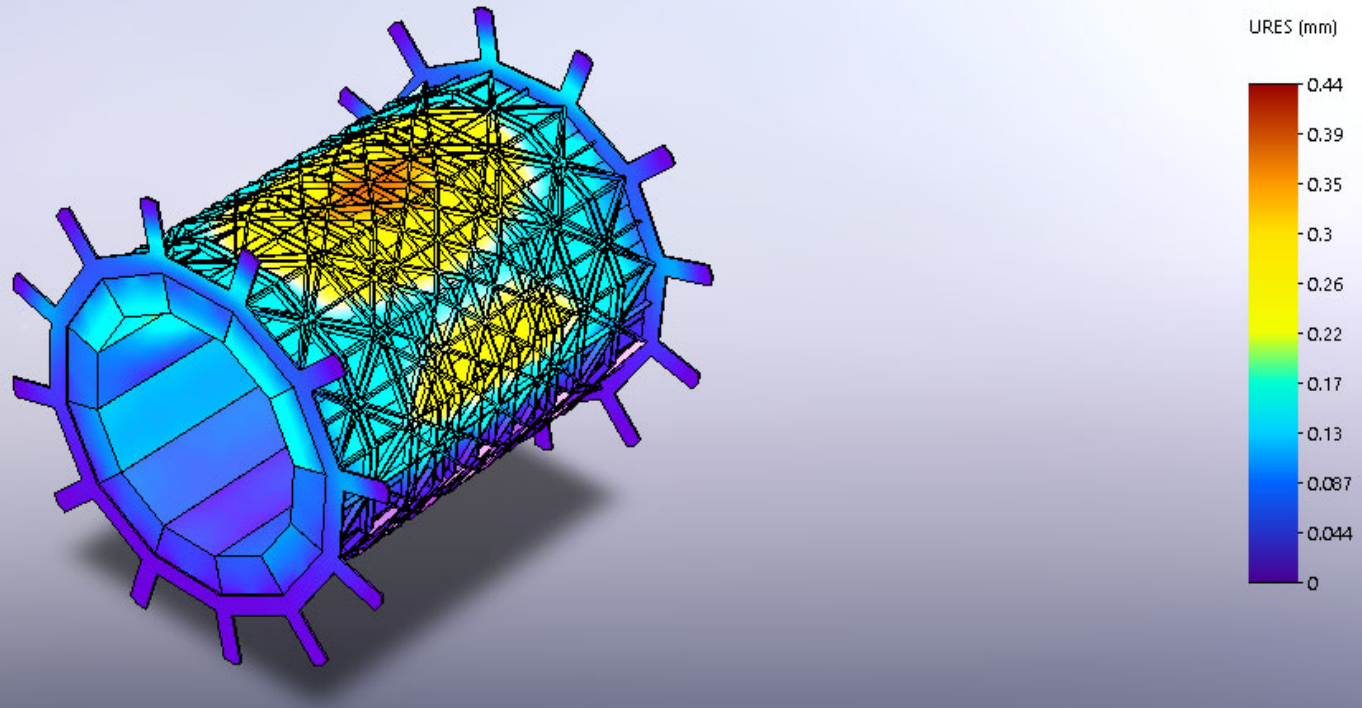
Mesh 7

- Volume: 0.815 m³.
- Works with Aluminum, Titanium, Stainless Steel alloys.
- Uniform width to all beams (19mm).



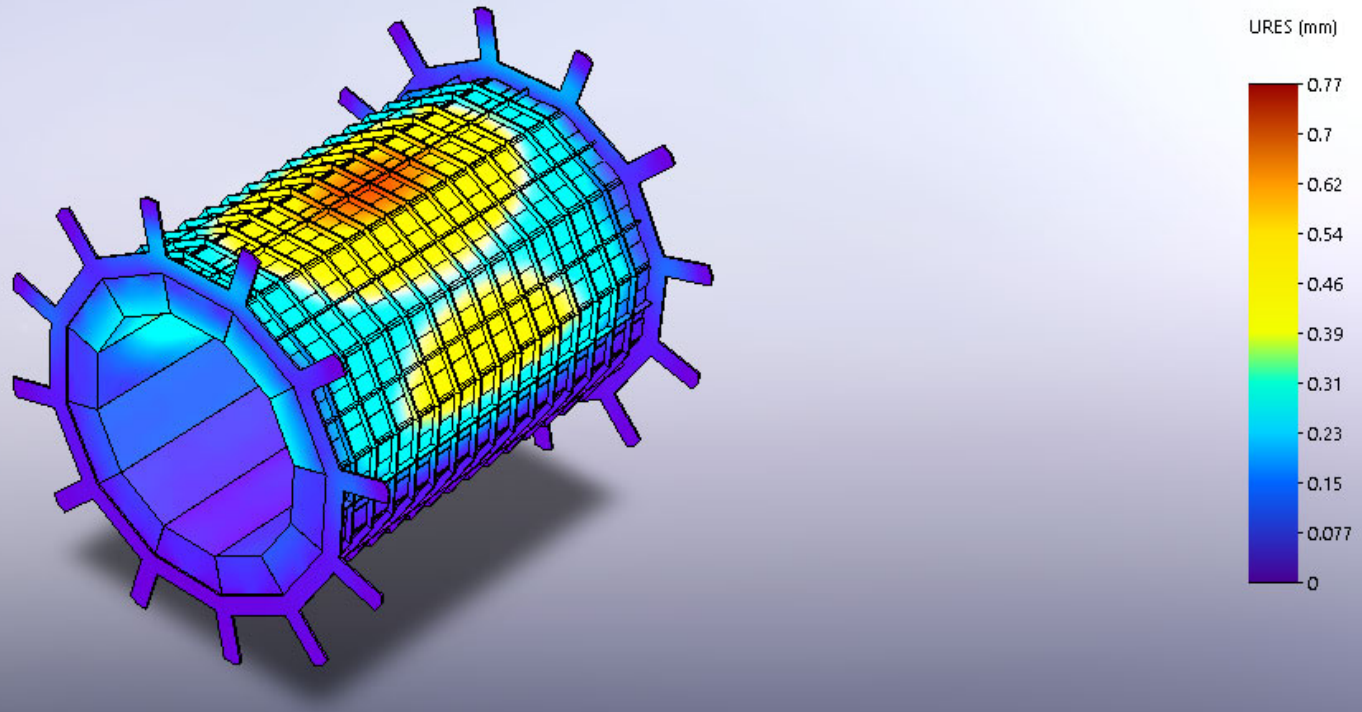
Mesh 8

- Volume: 0.848 m³.
- Works with aluminum, titanium, stainless steel alloys.
- Uniform width to all beams (19mm).



Mesh 9

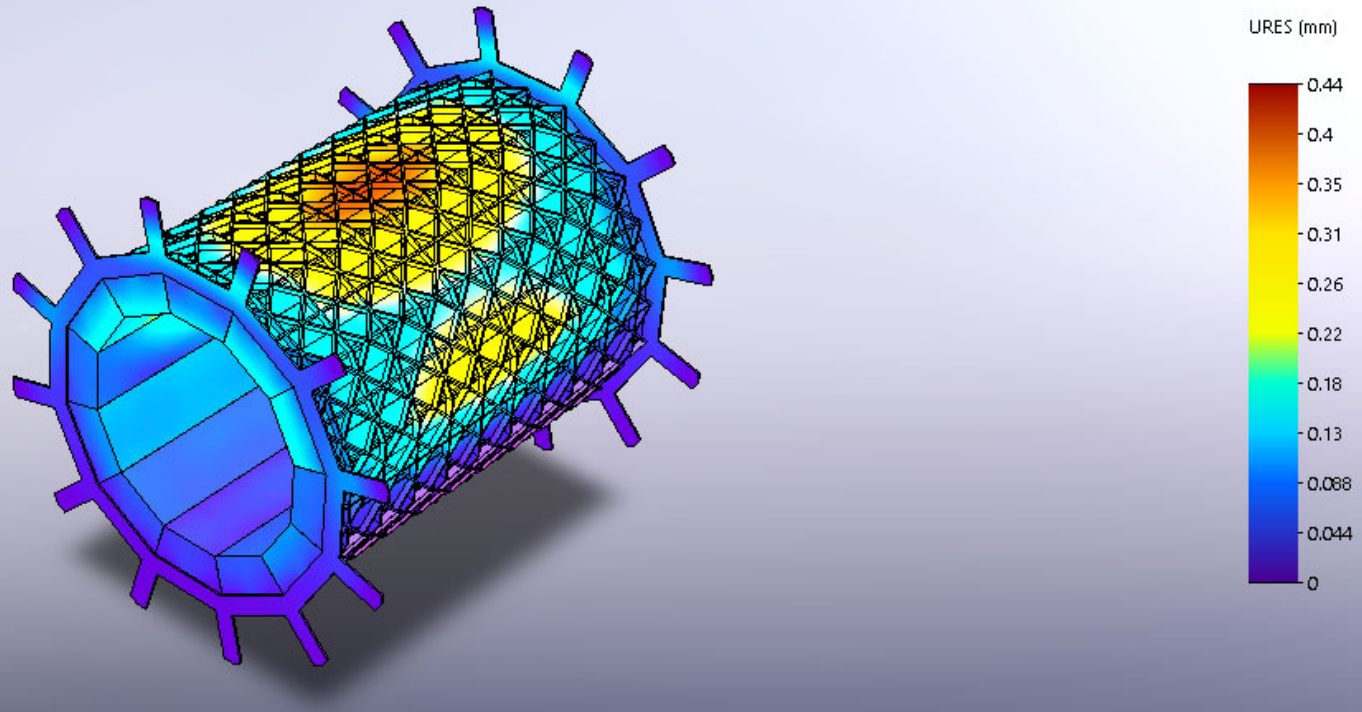
- Volume: 0.518 m³
- Will only work with Stainless Steel alloys.
- Uniform width to all beams (19mm).



*Isometric

Mesh 10

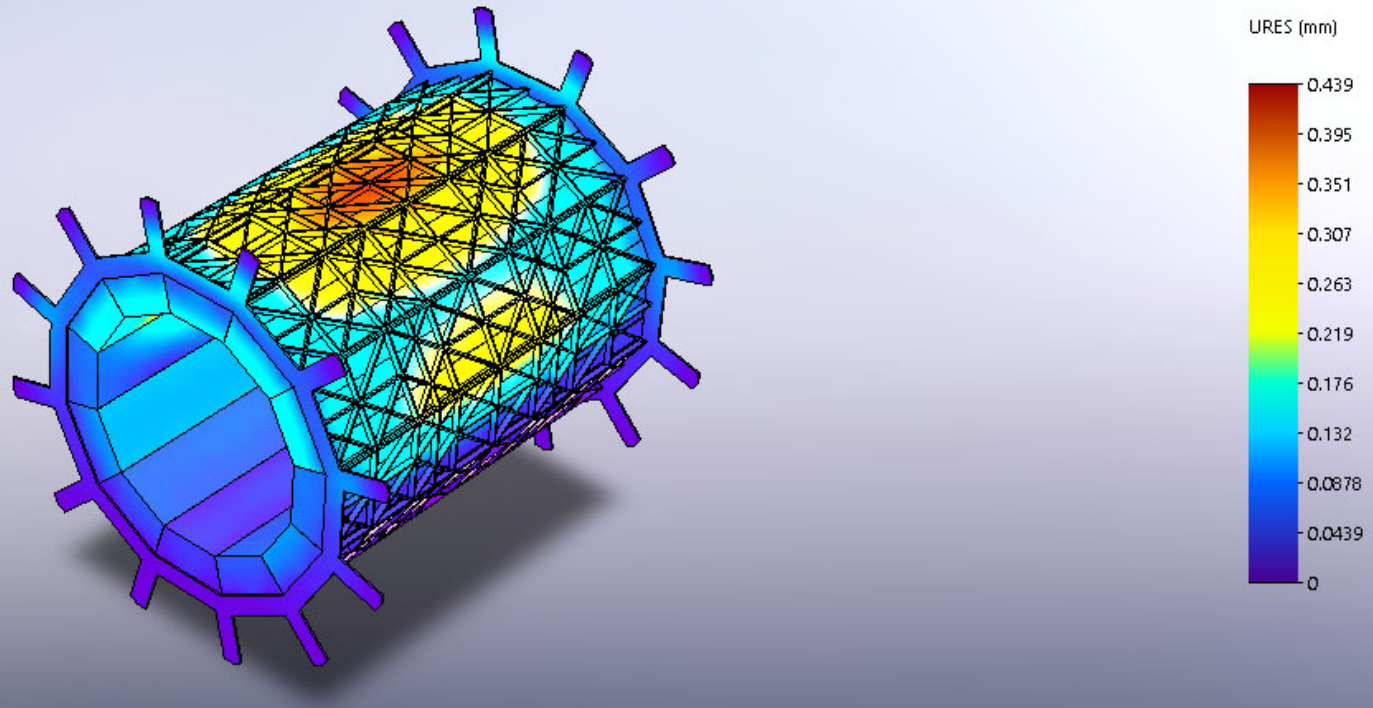
- Volume: 0.785m³
- Works with Aluminum, Titanium and stainless-steel alloys.
- Uniform width to all beams (19mm).



*Isometric

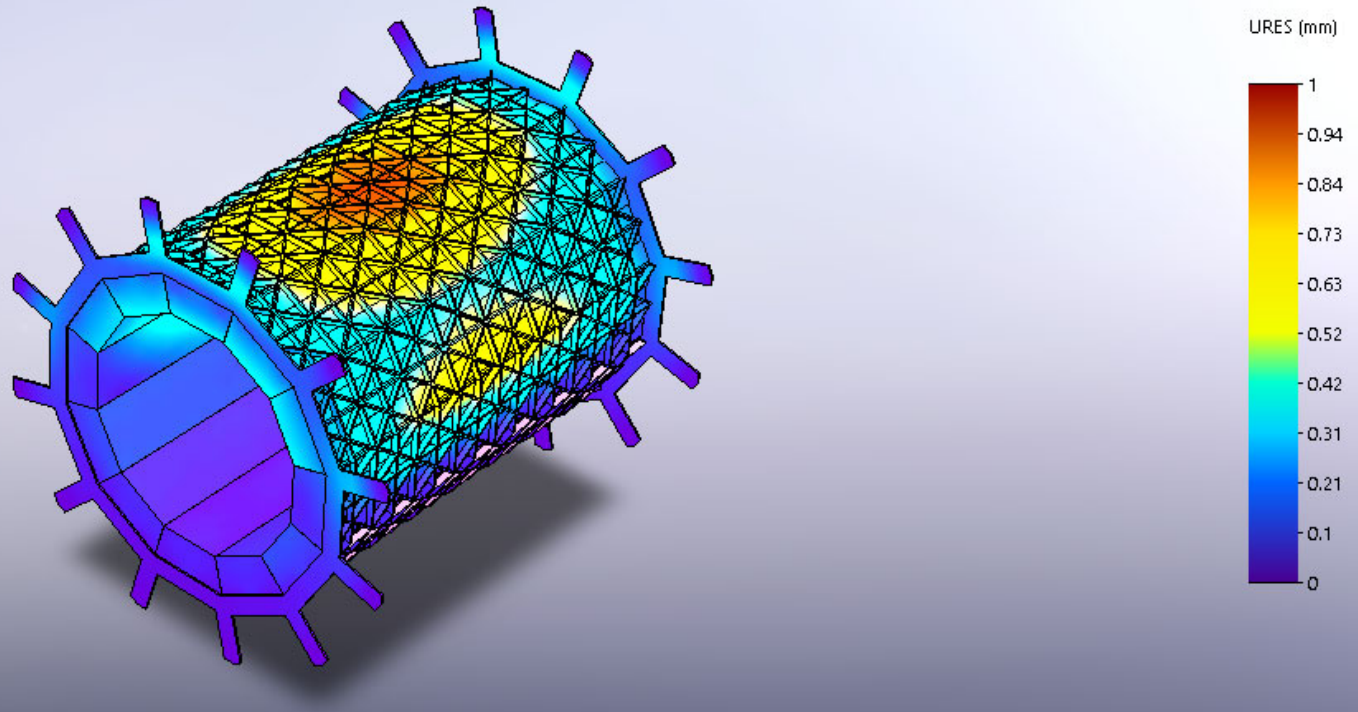
Mesh 11

- Volume: 0.693 m³.
- Works with Aluminum, Titanium and stainless-steel alloys.
- Uniform width to all beams (16mm).



Mesh 12

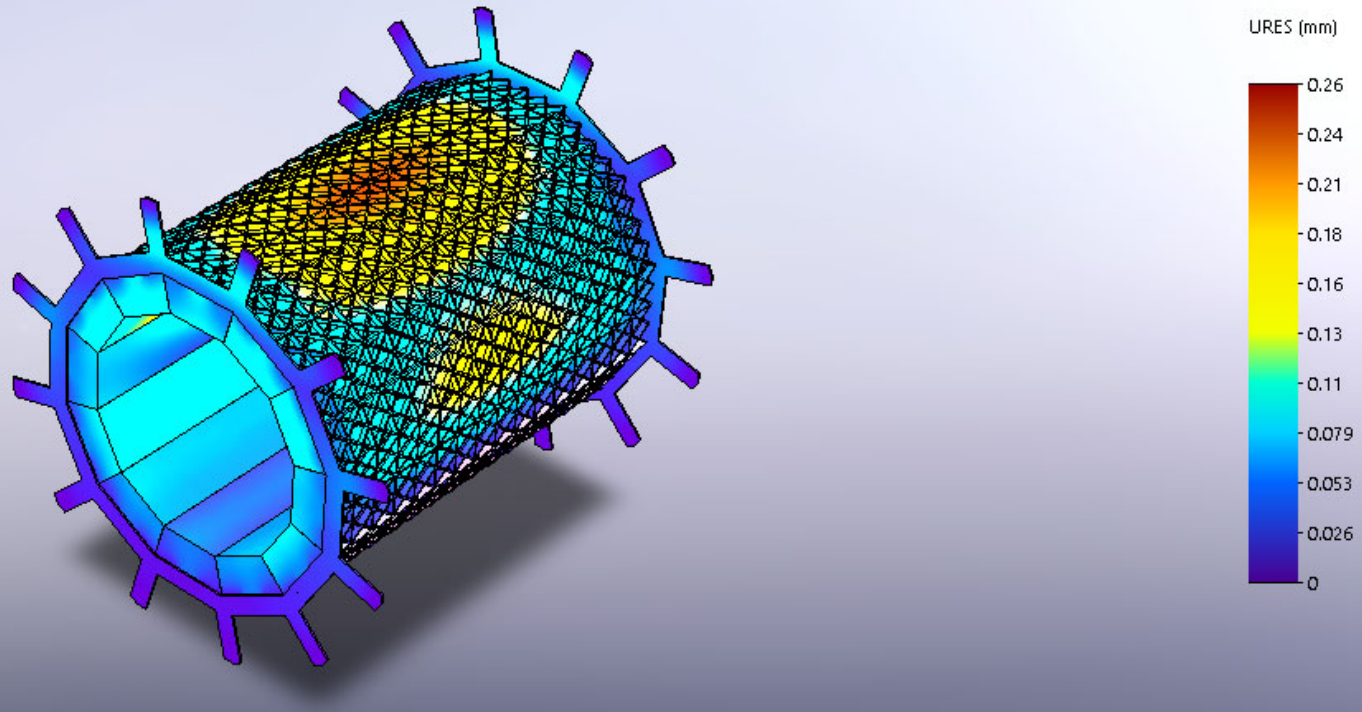
- Volume: 0.776 m³
- Works with Aluminum, Titanium and stainless-steel alloys.
- Uniform width to all beams (17mm).



*Isometric

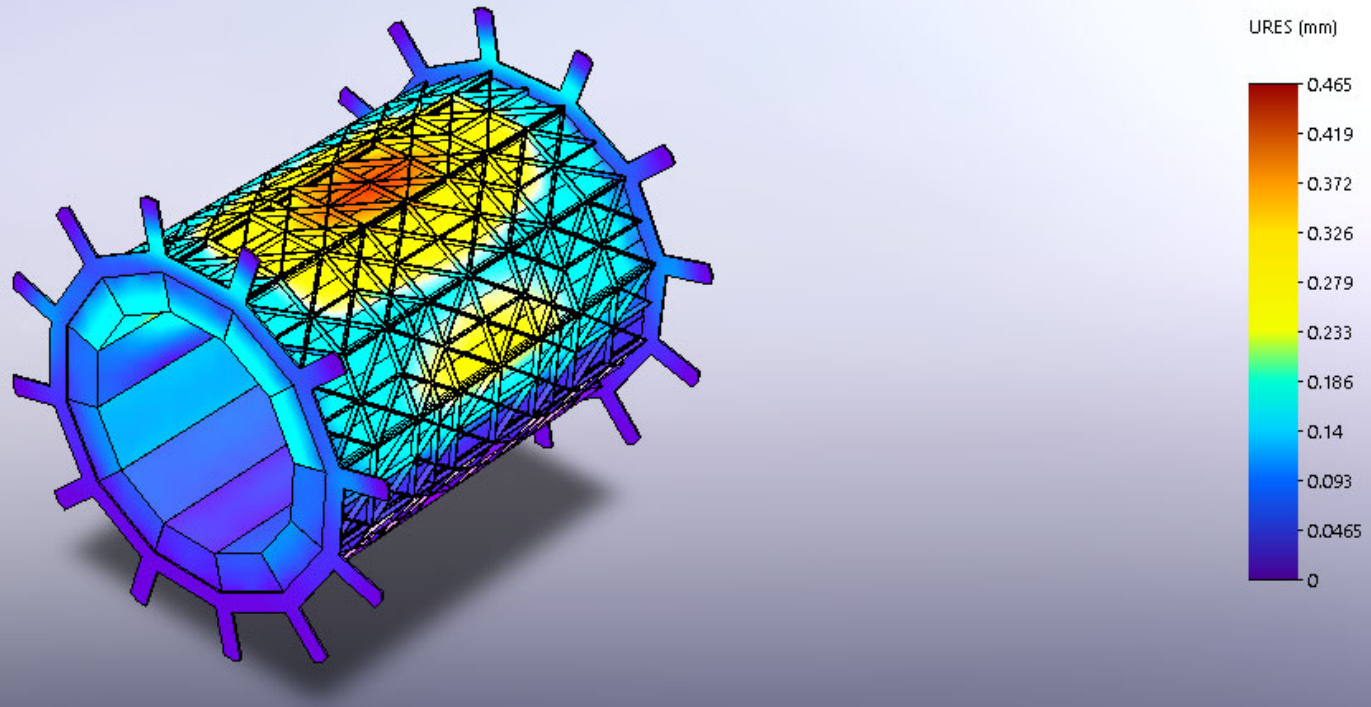
Mesh 13

- Volume: 0.983 m³.
- Works with Aluminum, Titanium and Stainless-Steel alloys.
- Uniform width to all beams (16mm).



Mesh 14

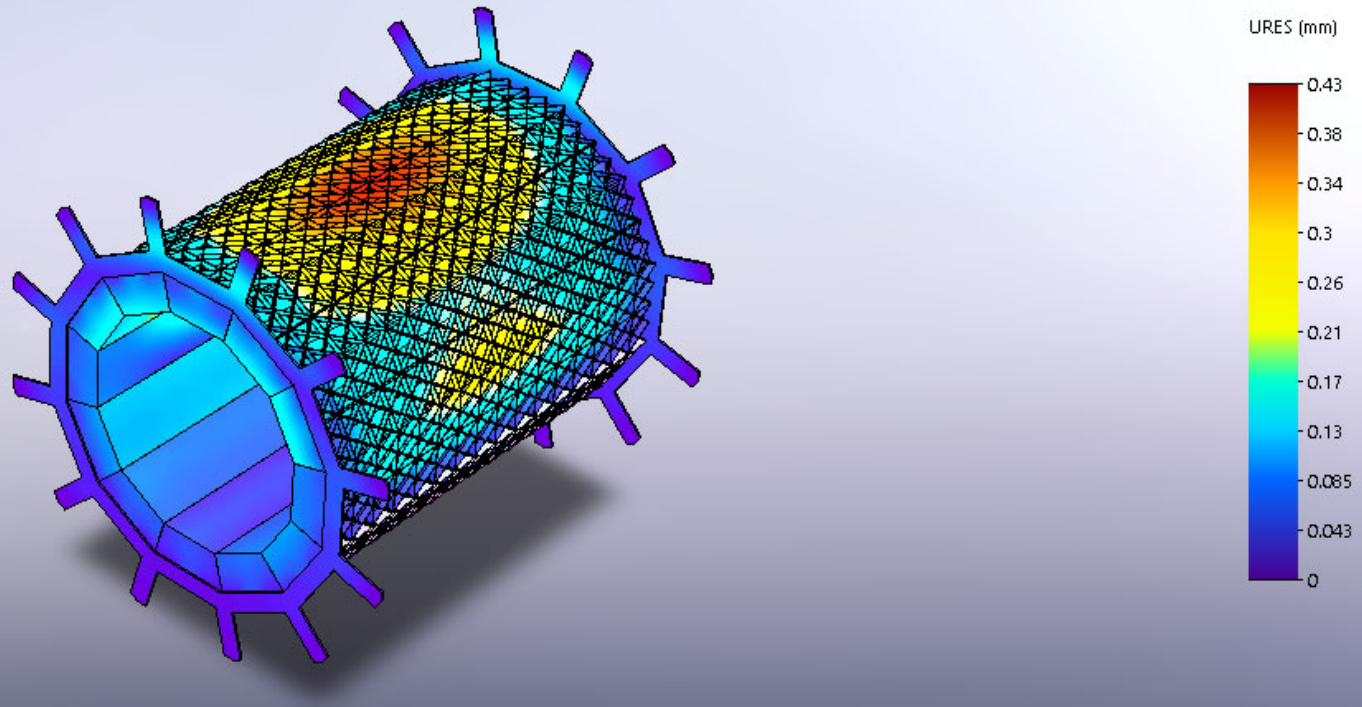
- Volume: 0.582 m³.
- Works with Aluminum, Titanium and stainless-steel alloys.
- Uniform width to all beams (13mm).

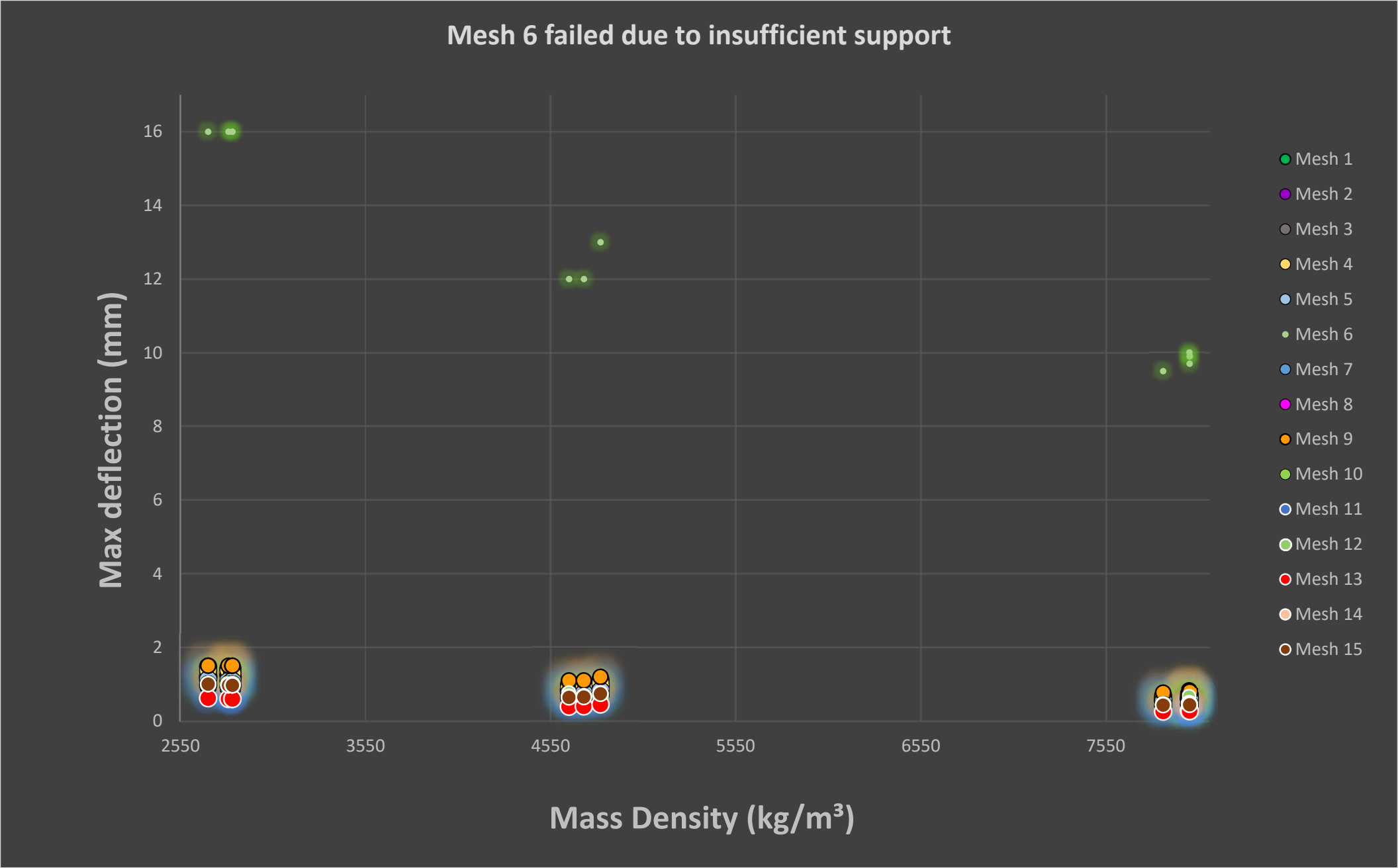


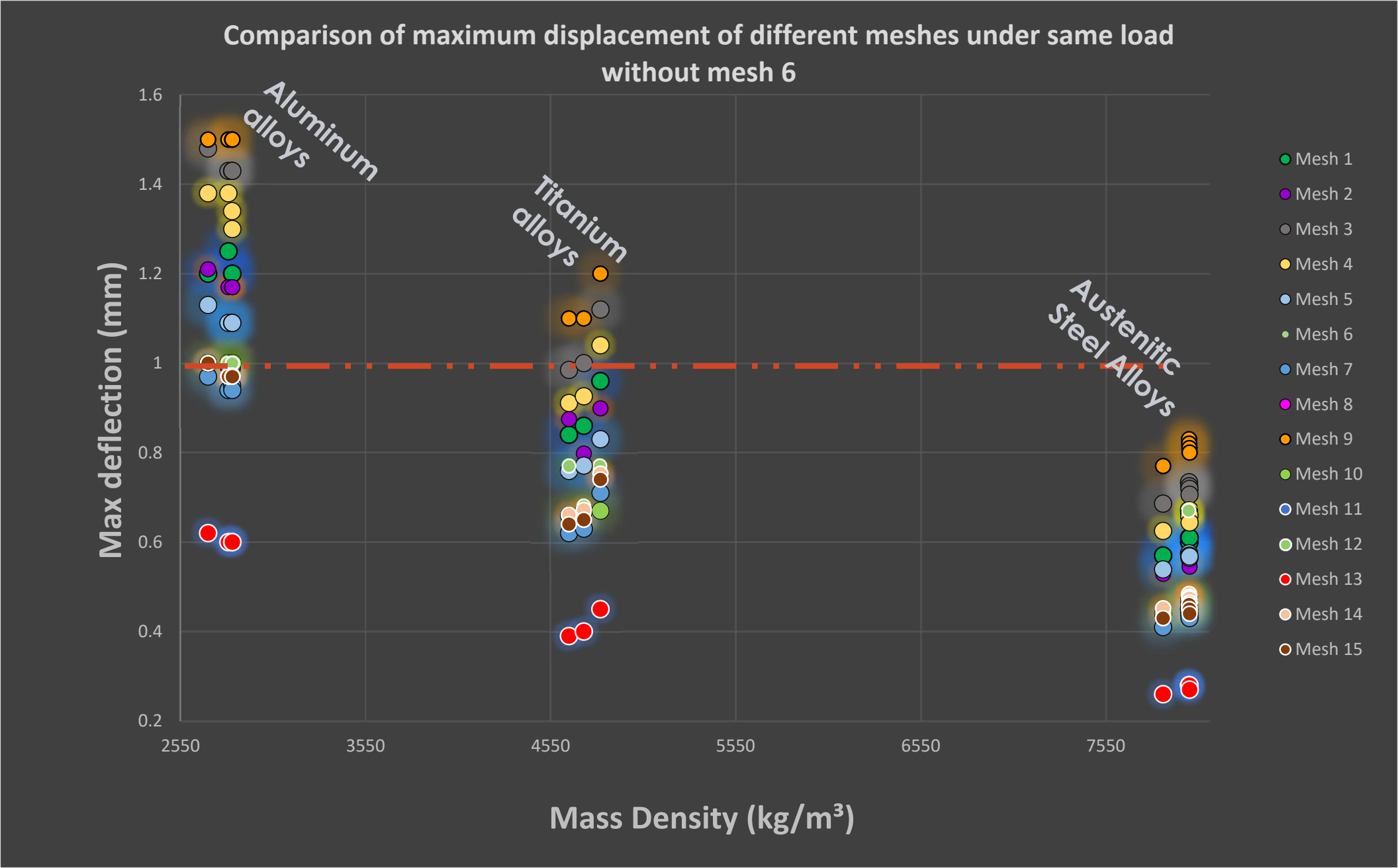
*Isometric

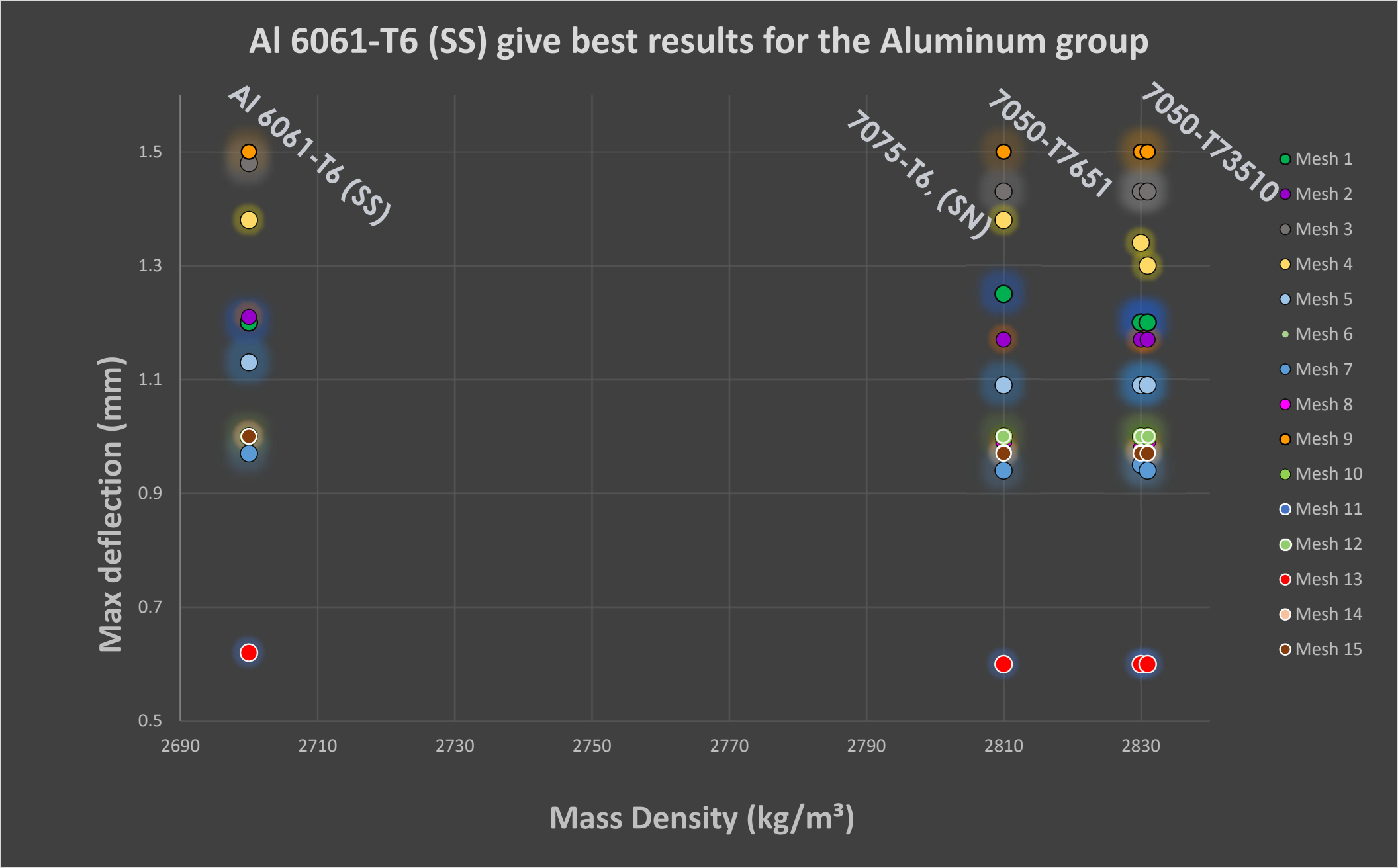
Mesh 15

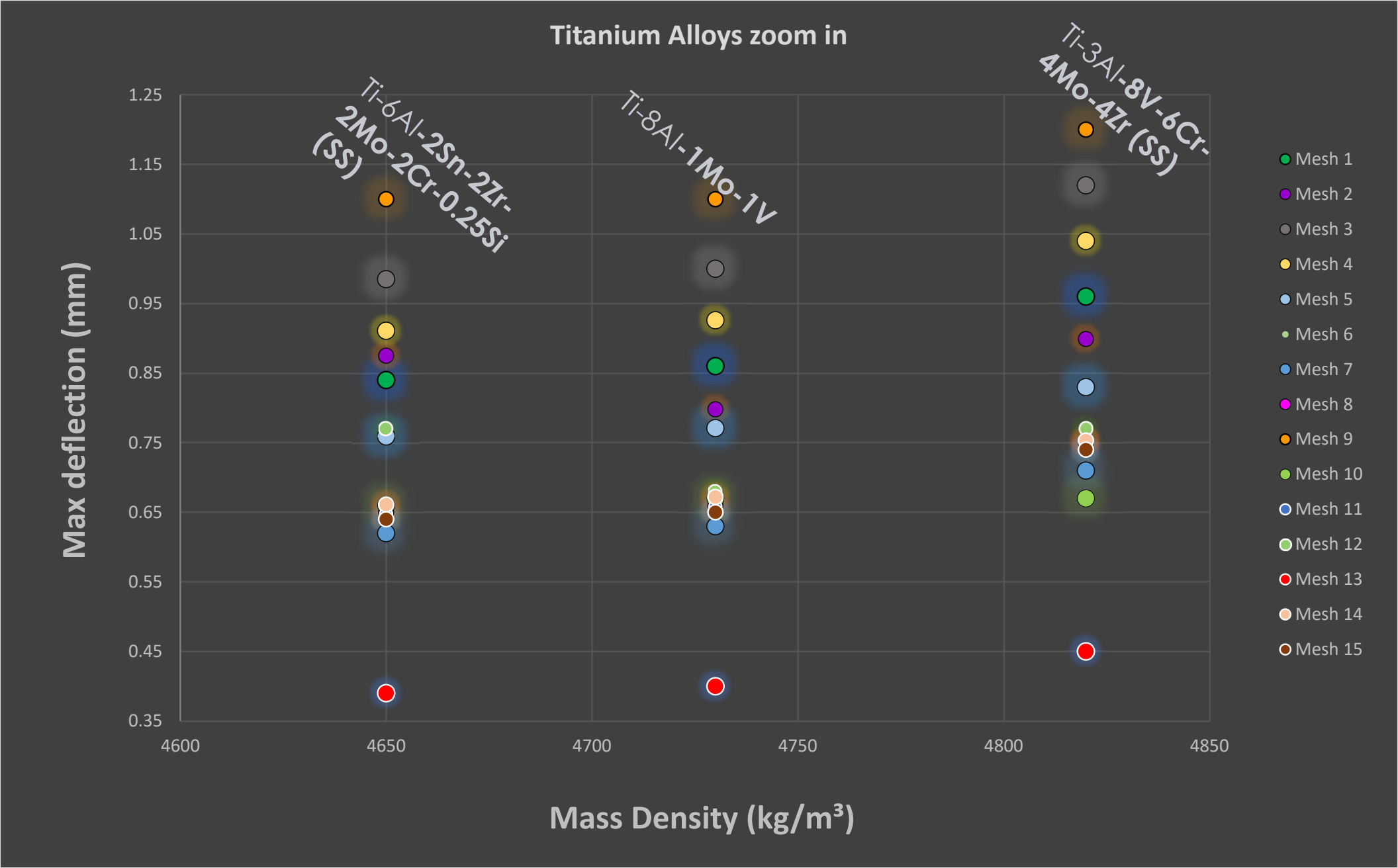
- Volume: 0.571 m³.
- Works with Aluminum, Titanium and stainless-steel alloys.
- Uniform width to all beams (6.5mm).

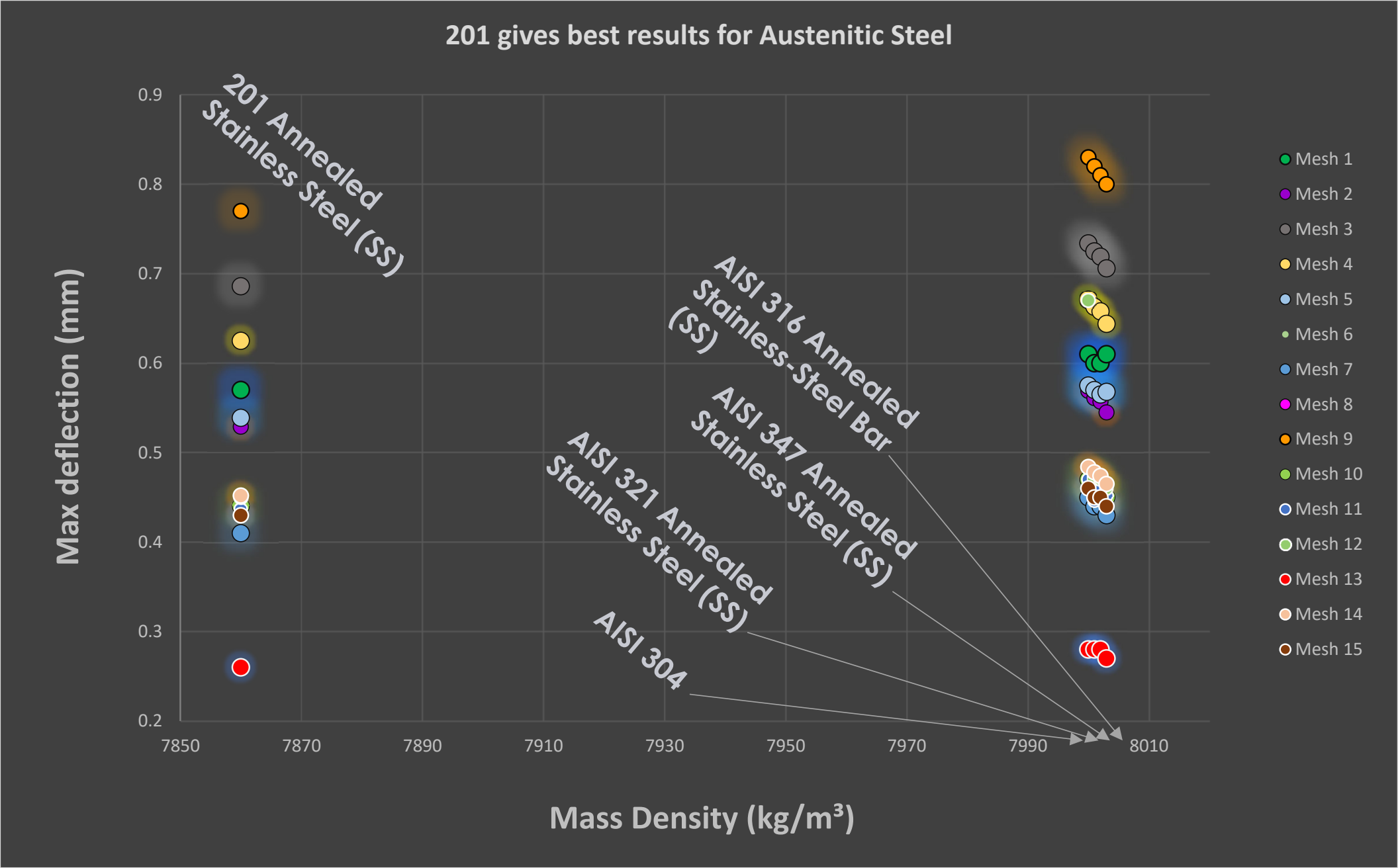



Mesh 6 failed due to insufficient support
Max deflection (mm)
16
14
12
10
8
6
4
2
0
2550
3550
4550
5550
6550
7550
Mass Density (kg/m³)
Mesh 1
Mesh 2
Mesh 3
Mesh 4
Mesh 5
Mesh 6
Mesh 7
Mesh 8
Mesh 9
Mesh 10
Mesh 11
Mesh 12
Mesh 13
Mesh 14
Mesh 15

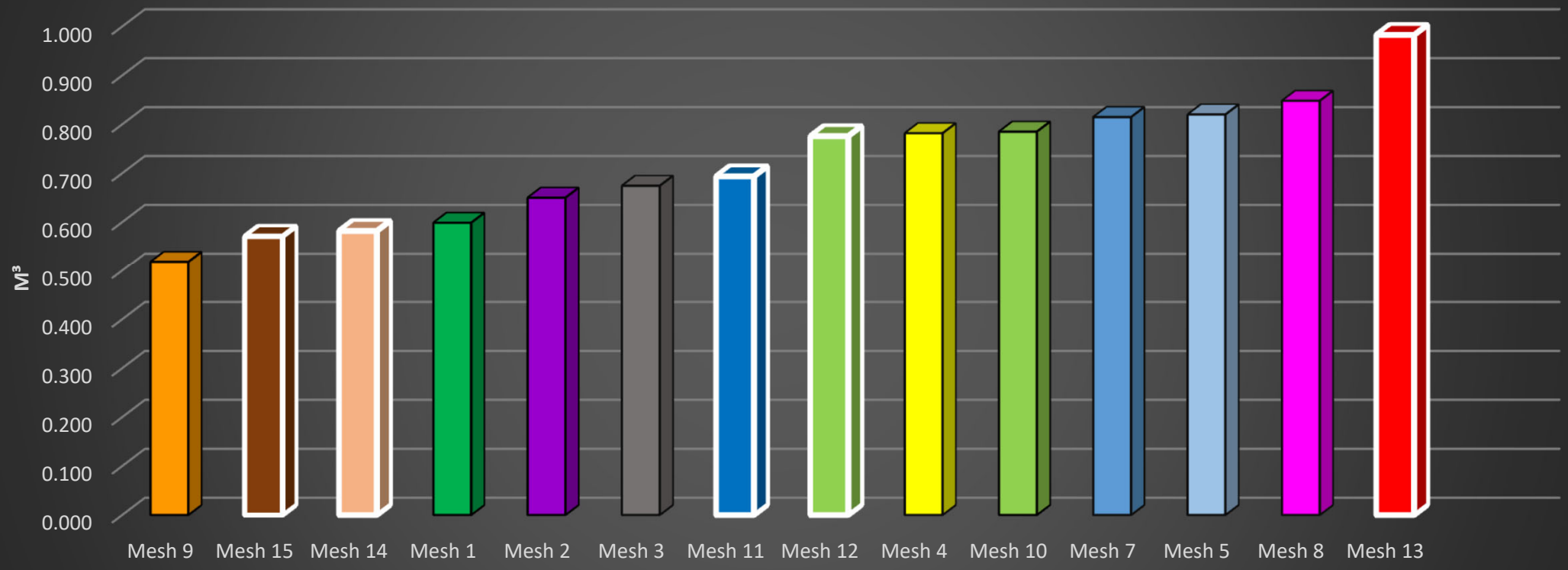

Comparison of maximum displacement of different meshes under same load without mesh 6
Aluminum alloys
Titanium alloys
Austenitic Steel Alloys
Max deflection (mm)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
2550
3550
4550
5550
6550
7550
Mass Density (kg/m³)
Mesh 1
Mesh 2
Mesh 3
Mesh 4
Mesh 5
Mesh 6
Mesh 7
Mesh 8
Mesh 9
Mesh 10
Mesh 11
Mesh 12
Mesh 13
Mesh 14
Mesh 15

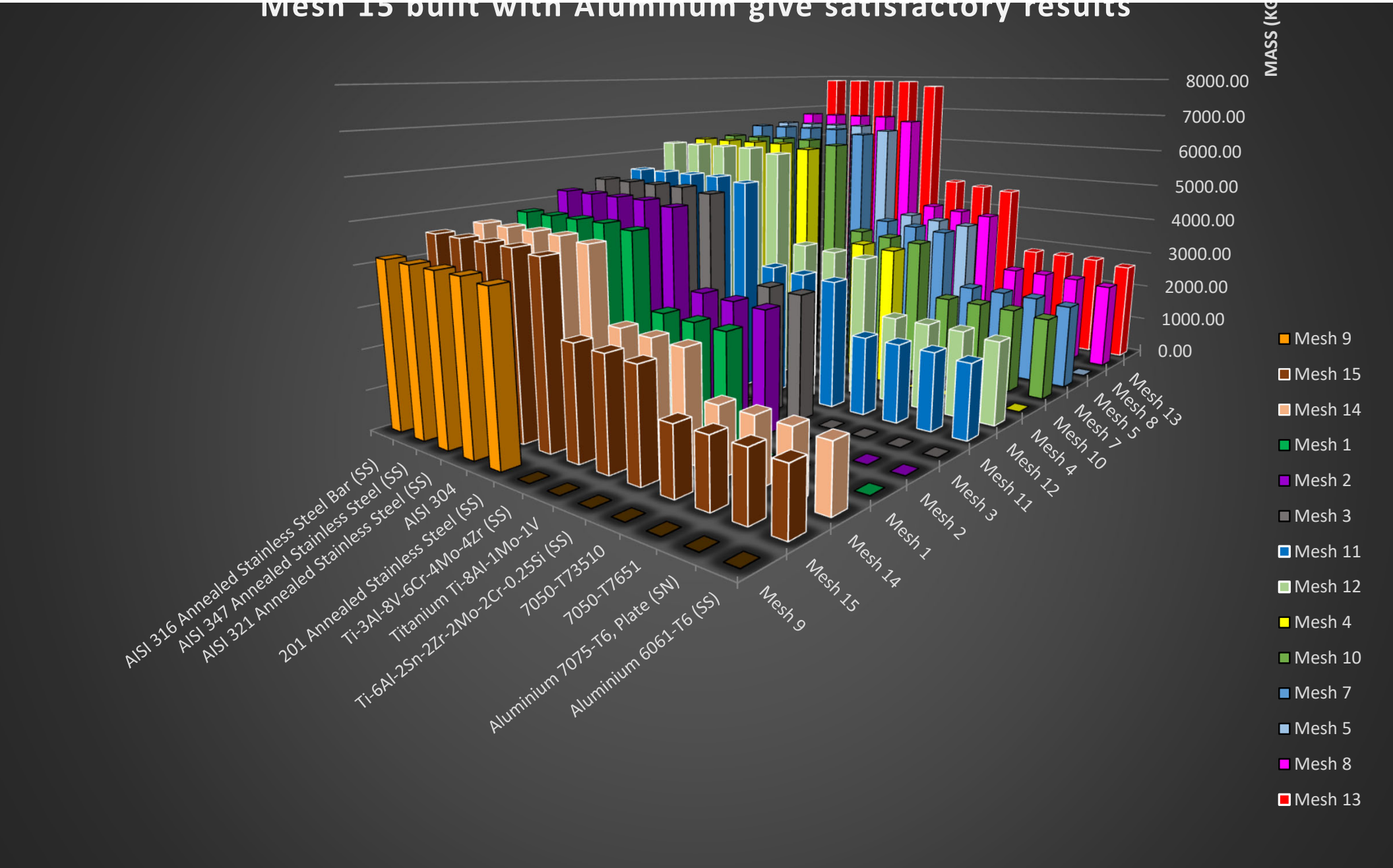

Al 6061-T6 (SS) give best results for the Aluminum group
Al 6061-T6 (SS)
7075-T6, (SN)
7050-T7651
7050-T73510
Max deflection (mm)
1.5
1.3
1.1
0.9
0.7
0.5
2690
2710
2730
2750
2770
2790
2810
2830
Mass Density (kg/m³)
Mesh 1
Mesh 2
Mesh 3
Mesh 4
Mesh 5
Mesh 6
Mesh 7
Mesh 8
Mesh 9
Mesh 10
Mesh 11
Mesh 12
Mesh 13
Mesh 14
Mesh 15


Titanium Alloys zoom in
Ti-6Al-2Sn-2Zr-2Mo-2Cr-0.25Si (SS)
Ti-8Al-1Mo-1V
Ti-3Al-8V-6Cr-4Mo-4Zr (SS)
Max deflection (mm)
1.25
1.15
1.05
0.95
0.85
0.75
0.65
0.55
0.45
0.35
4600
4650
4700
4750
4800
4850
Mass Density (kg/m³)
Mesh 1
Mesh 2
Mesh 3
Mesh 4
Mesh 5
Mesh 6
Mesh 7
Mesh 8
Mesh 9
Mesh 10
Mesh 11
Mesh 12
Mesh 13
Mesh 14
Mesh 15

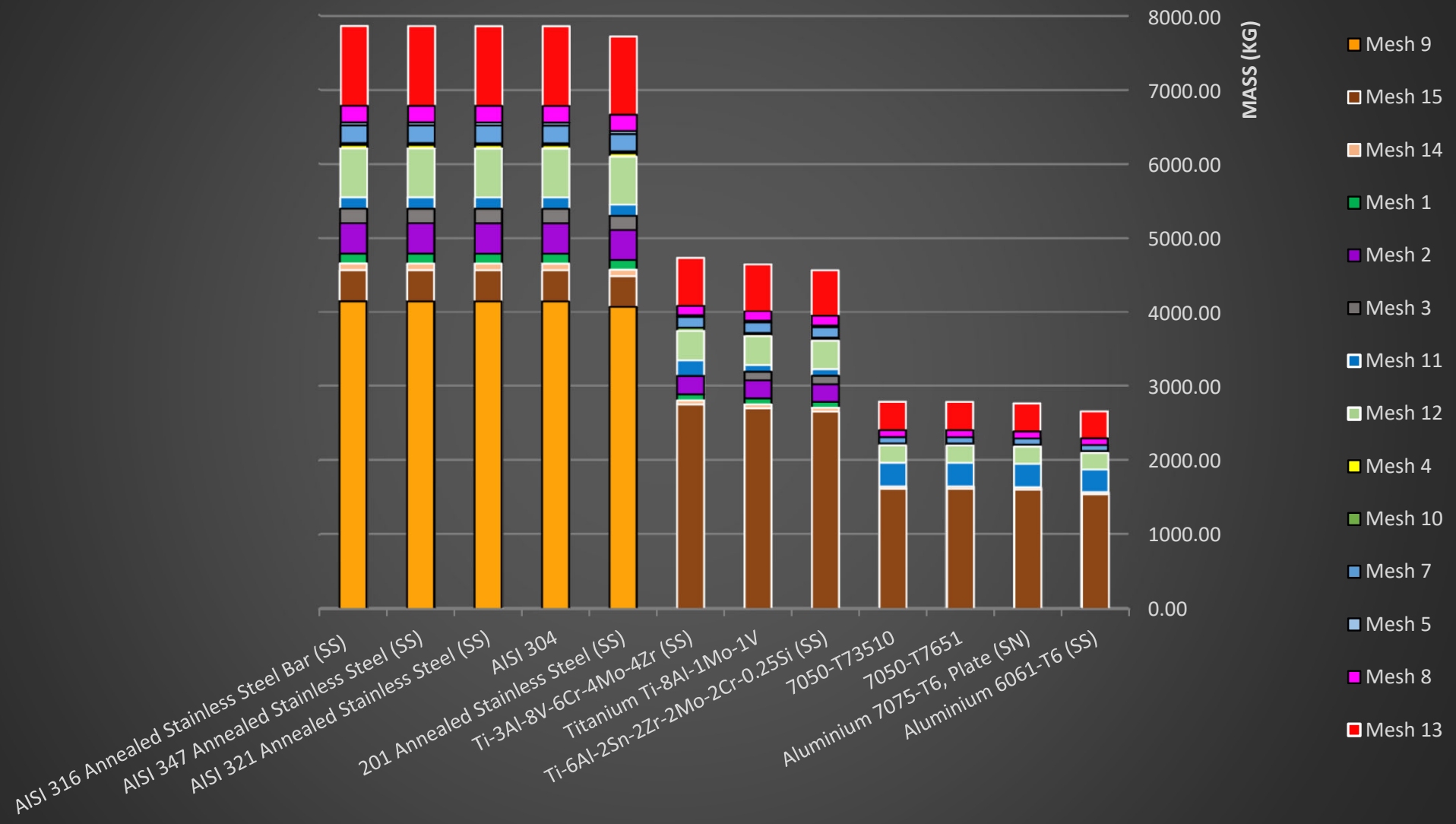

201 gives best results for Austenitic Steel
201 Annealed Stainless Steel (SS)
AISI 316 Annealed Stainless-Steel Bar (SS)
AISI 347 Annealed Stainless Steel (SS)
AISI 321 Annealed Stainless Steel (SS)
AISI 304
Max deflection (mm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
7850
7870
7890
7910
7930
7950
7970
7990
8010
Mass Density (kg/m³)
Mesh 1
Mesh 2
Mesh 3
Mesh 4
Mesh 5
Mesh 6
Mesh 7
Mesh 8
Mesh 9
Mesh 10
Mesh 11
Mesh 12
Mesh 13
Mesh 14
Mesh 15

Mesh Volume


1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
M³
Mesh 9
Mesh 15
Mesh 14
Mesh 1
Mesh 2
Mesh 3
Mesh 11
Mesh 12
Mesh 4
Mesh 10
Mesh 7
Mesh 5
Mesh 8
Mesh 13


Mesh 15 built with Aluminum give satisfactory results
MASS (KG
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
AISI 316 Annealed Stainless Steel Bar (SS)
AISI 347 Annealed Stainless Steel (SS)
AISI 321 Annealed Stainless Steel (SS)
AISI 304
201 Annealed Stainless Steel (SS)
Ti-3Al-8V-6Cr-4Mo-4Zr (SS)
Titanium Ti-8Al-1Mo-1V
Ti-6Al-2Sn-2Zr-2Mo-2Cr-0.25Si (SS)
7050-T73510
7050-T7651
Aluminium 7075-T6, Plate (SN)
Aluminium 6061-T6 (SS)
Mesh 9
Mesh 15
Mesh 14
Mesh 1
Mesh 2
Mesh 3
Mesh 11
Mesh 12
Mesh 4
Mesh 10
Mesh 7
Mesh 5
Mesh 8
Mesh 13

Mass per configuration (material and Mesh)



Summary

- Roughly speaking the most significant support component is the differential component.
- Mesh7 and Meshes 10-15 meet all requirements.
- Next steps: narrowing the beams while making the mesh denser.