Stress simulation on a round wheel W target

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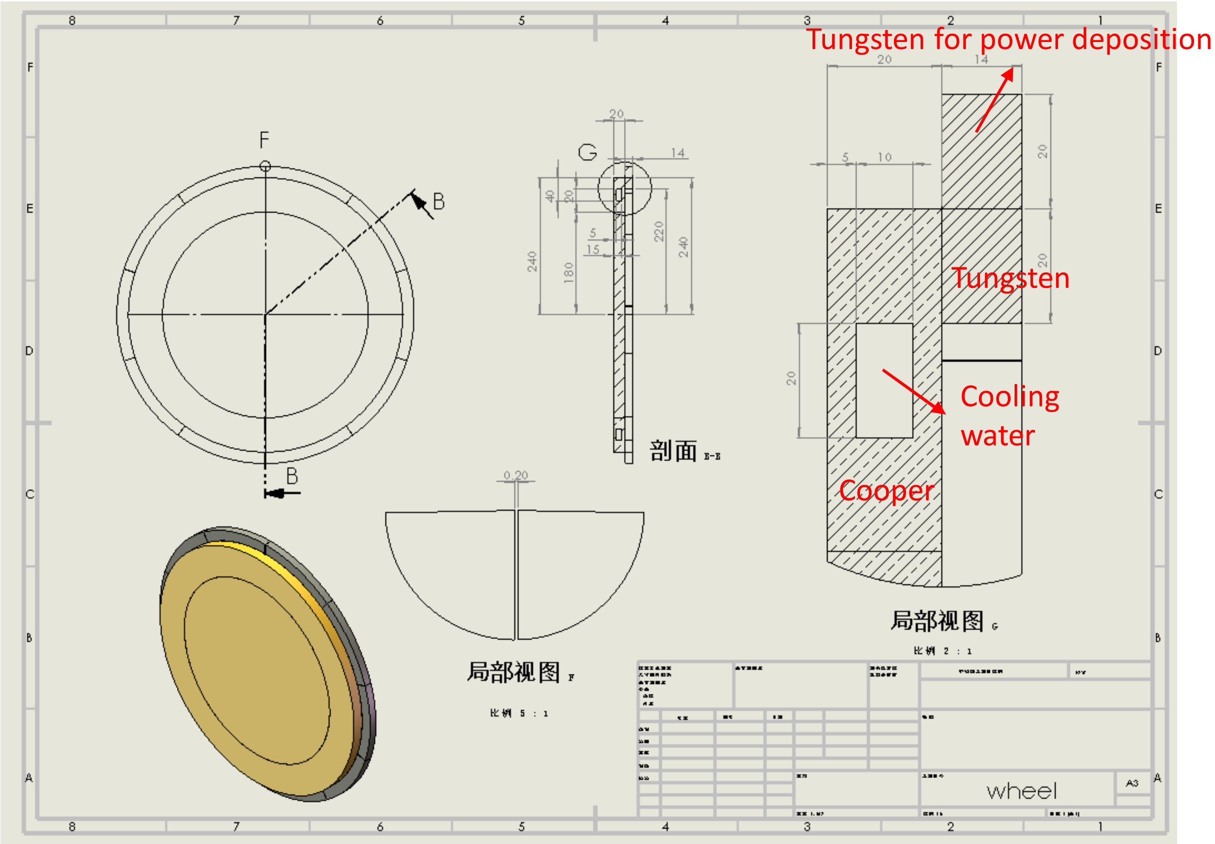
Outline

- Introduction
- Simulation results of full ring and sliced ring
- Summary

Introduction

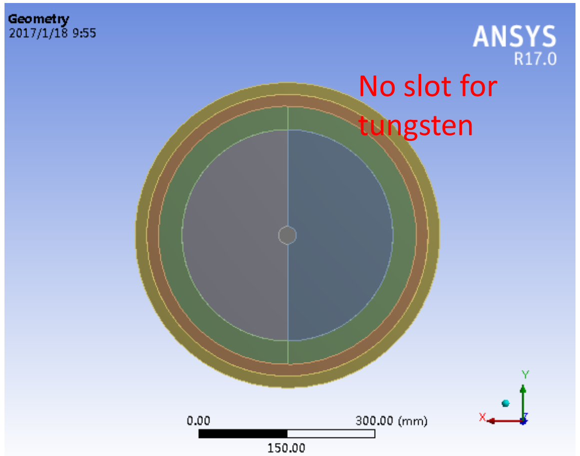
- Main structure of the model



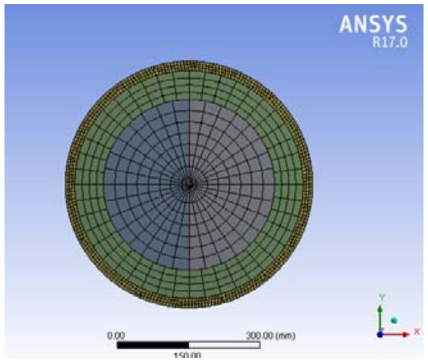
- For model 1, there is no slots in tungsten part;
- For model 2, the tungsten is sliced to 10 parts by the slot with a width of 0.2mm;
- An intermetallic contact between the W and the Cu, like brazing, is assumed, with a thermal conductance of 2 W/(cm^2 ▪K)
- The average power is deposited uniformly in time and space over the top part of the W. In total about 35 Kw
- The water temperature is 50K.

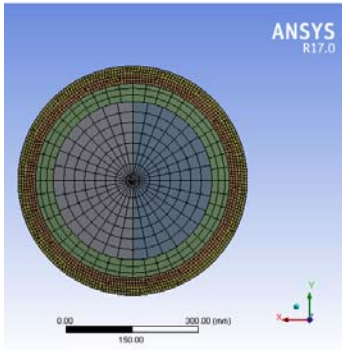
Model-1

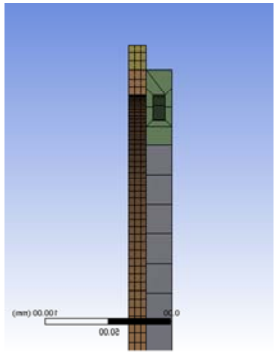
Model-1



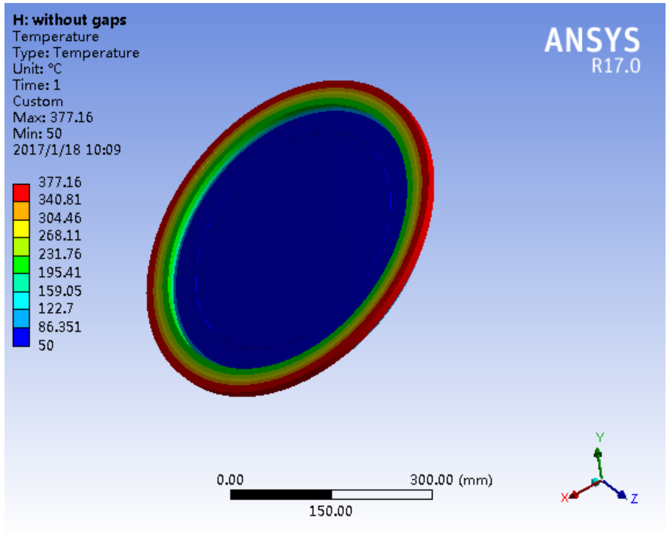
- **Boundaries:**
  - Water Temperature: 50C
  - Thermal Conductance for both of water-Cu and W –Cu surface: 0.02W/mm^2
  - Power is only deposited in the top part of the W with 0.0795W/mm^3
  - There is a Cu bar with diameter of 30mm in the center. We fixed it.

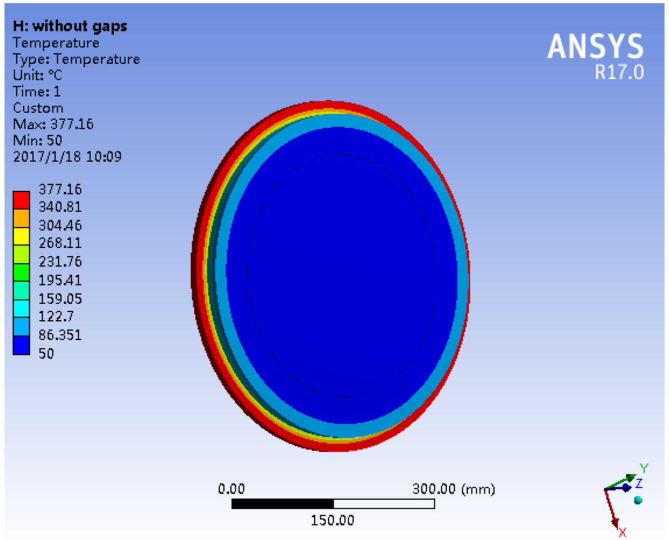


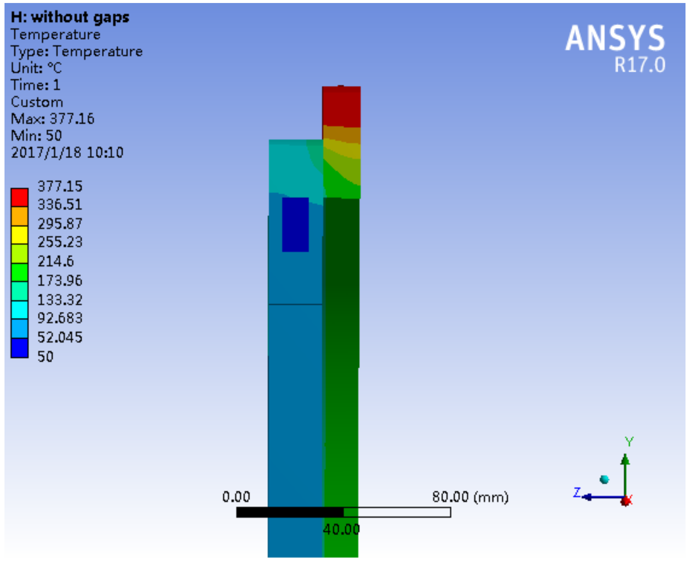




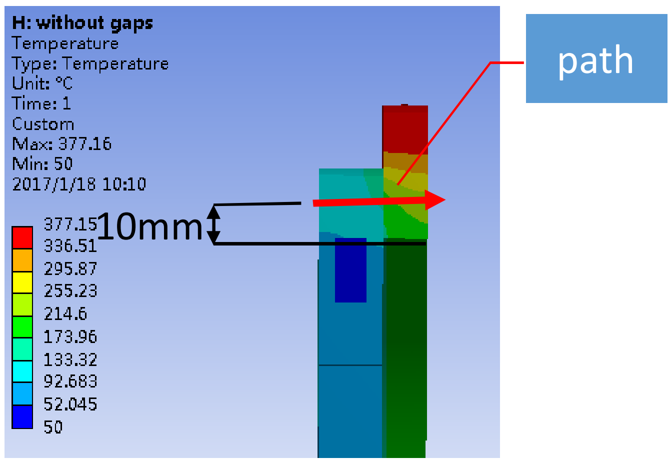
Results: Temperature distribution



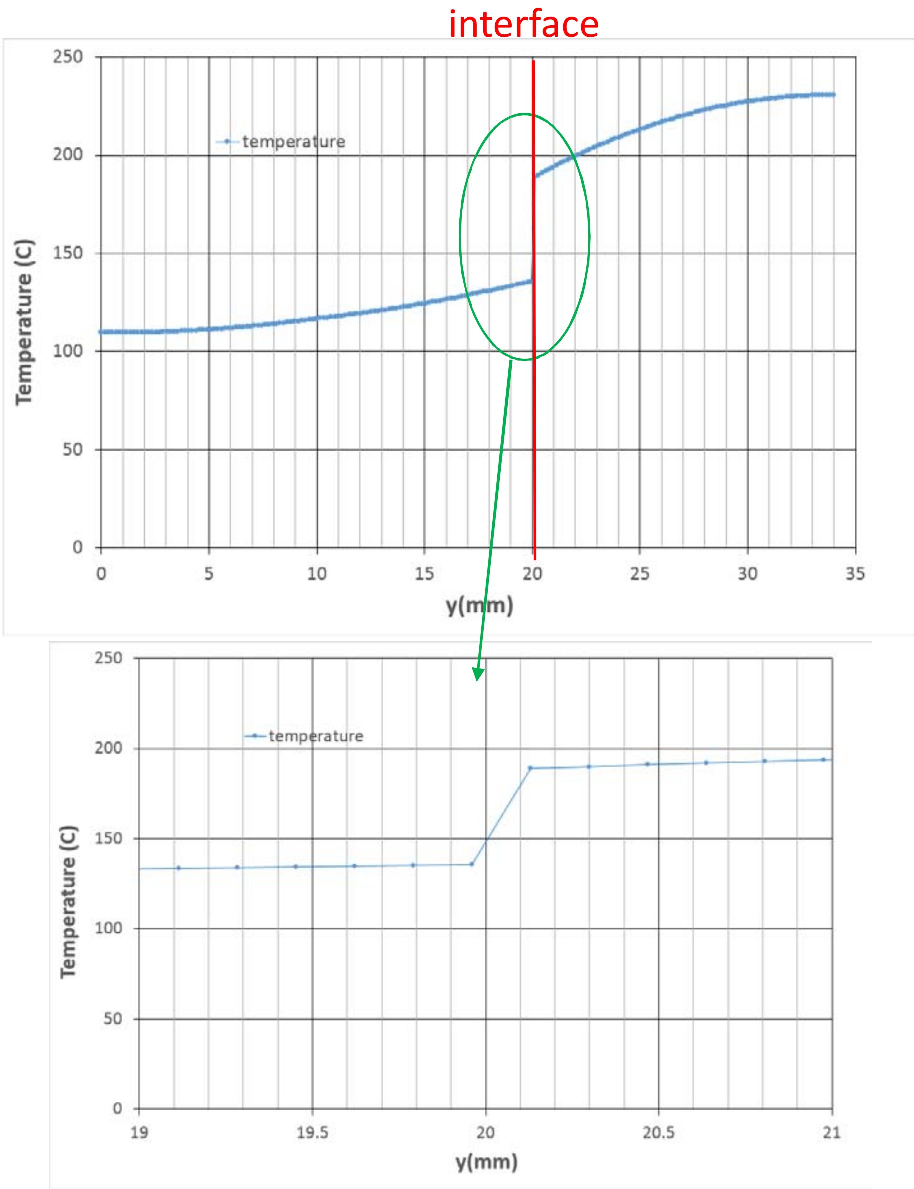




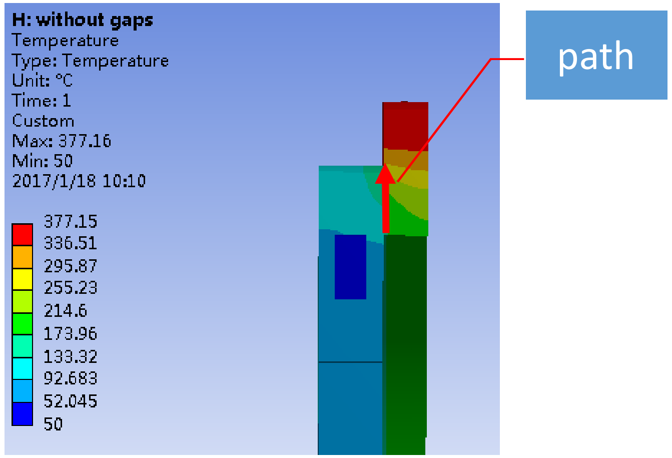
Temperature

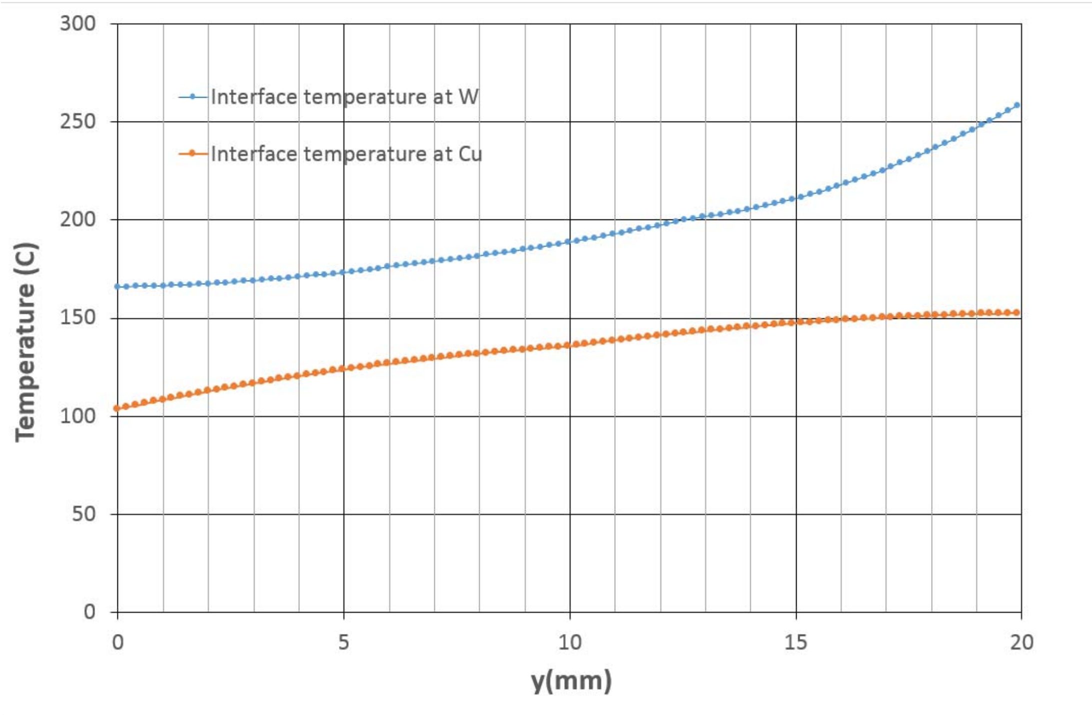


There will be a temperature jump at the interface.



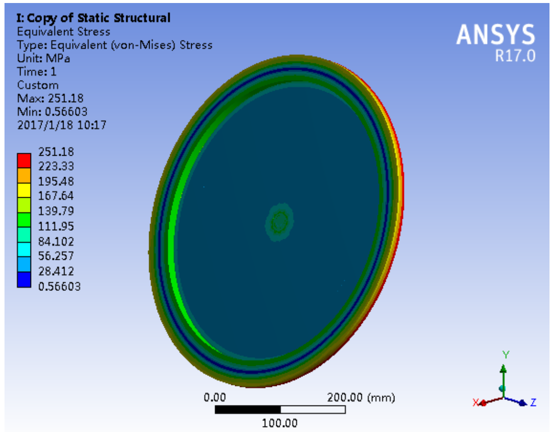
Temperature

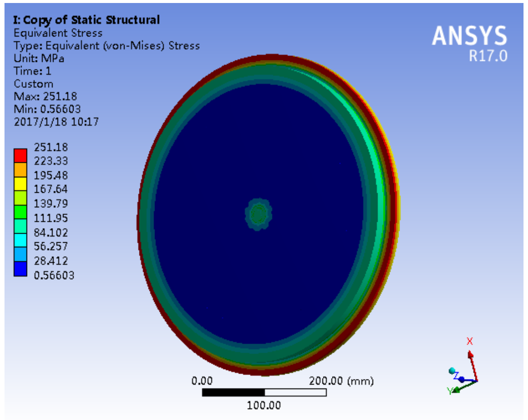


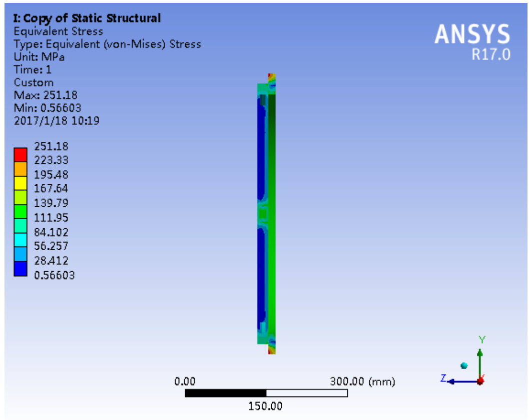


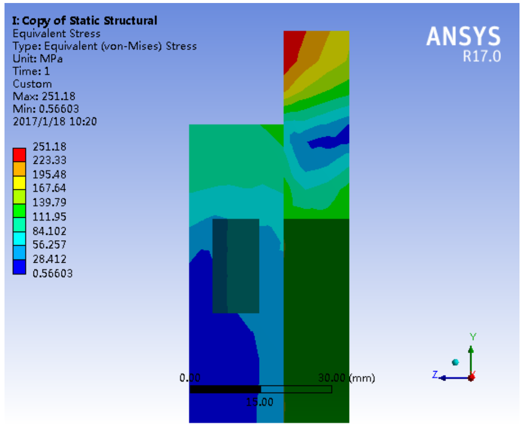
The temperature is obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

Results: v. M. Stresses

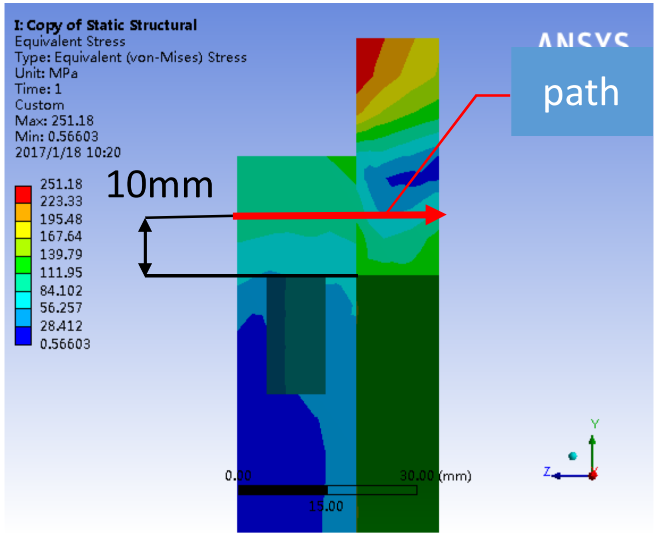




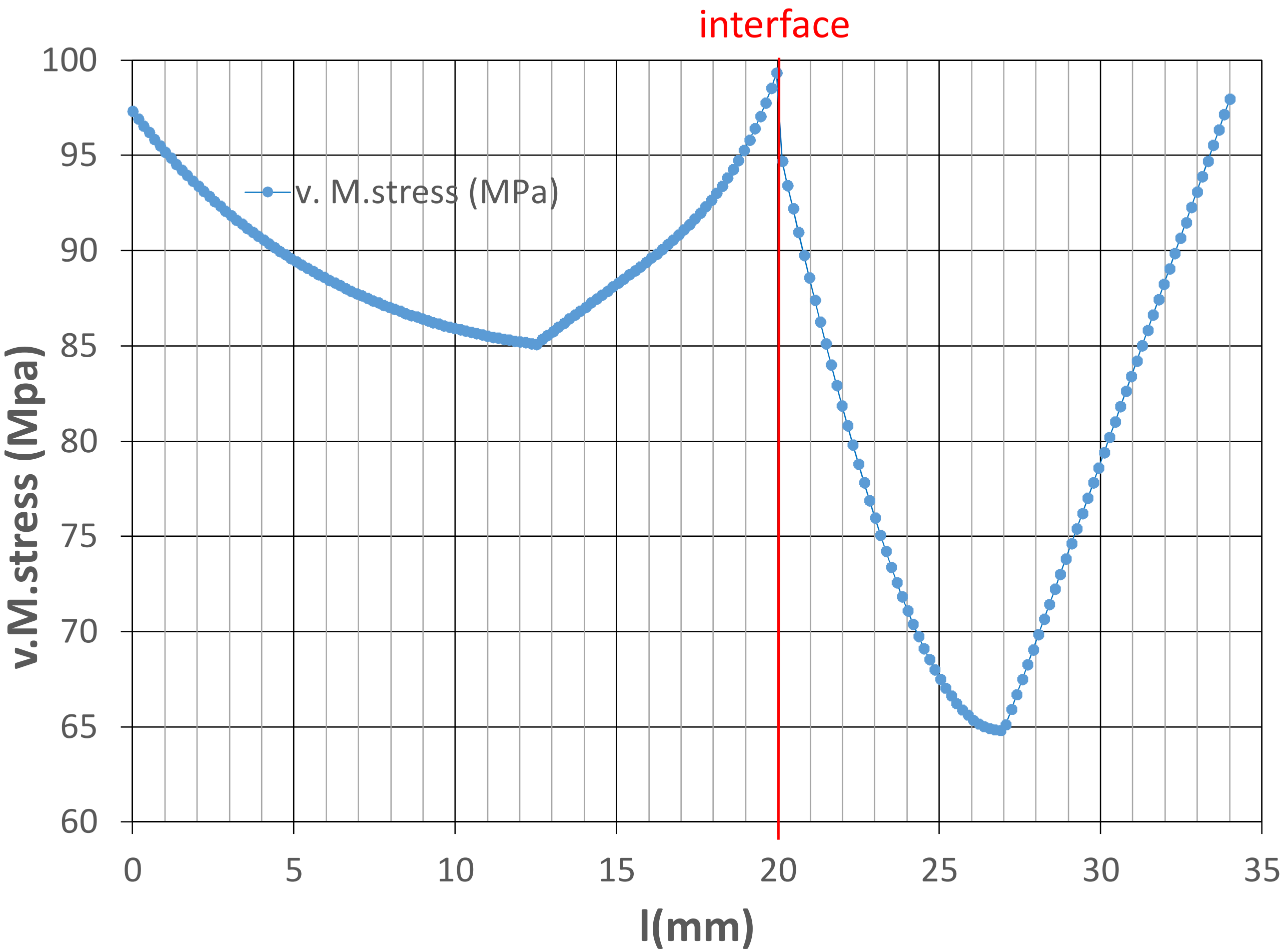




v. M. stresses

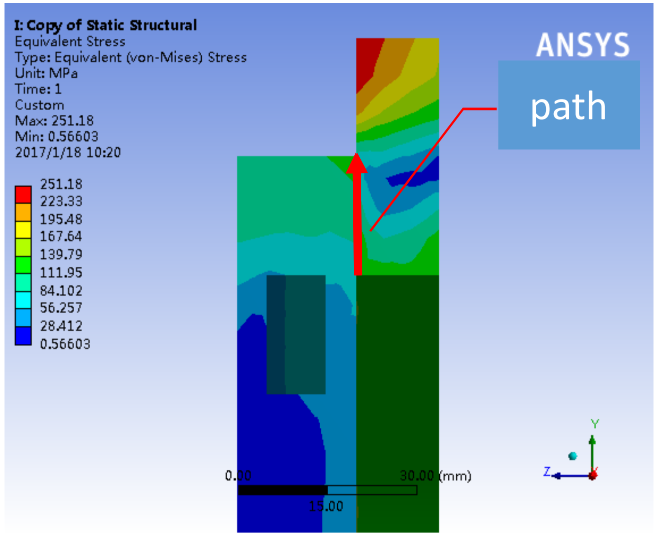


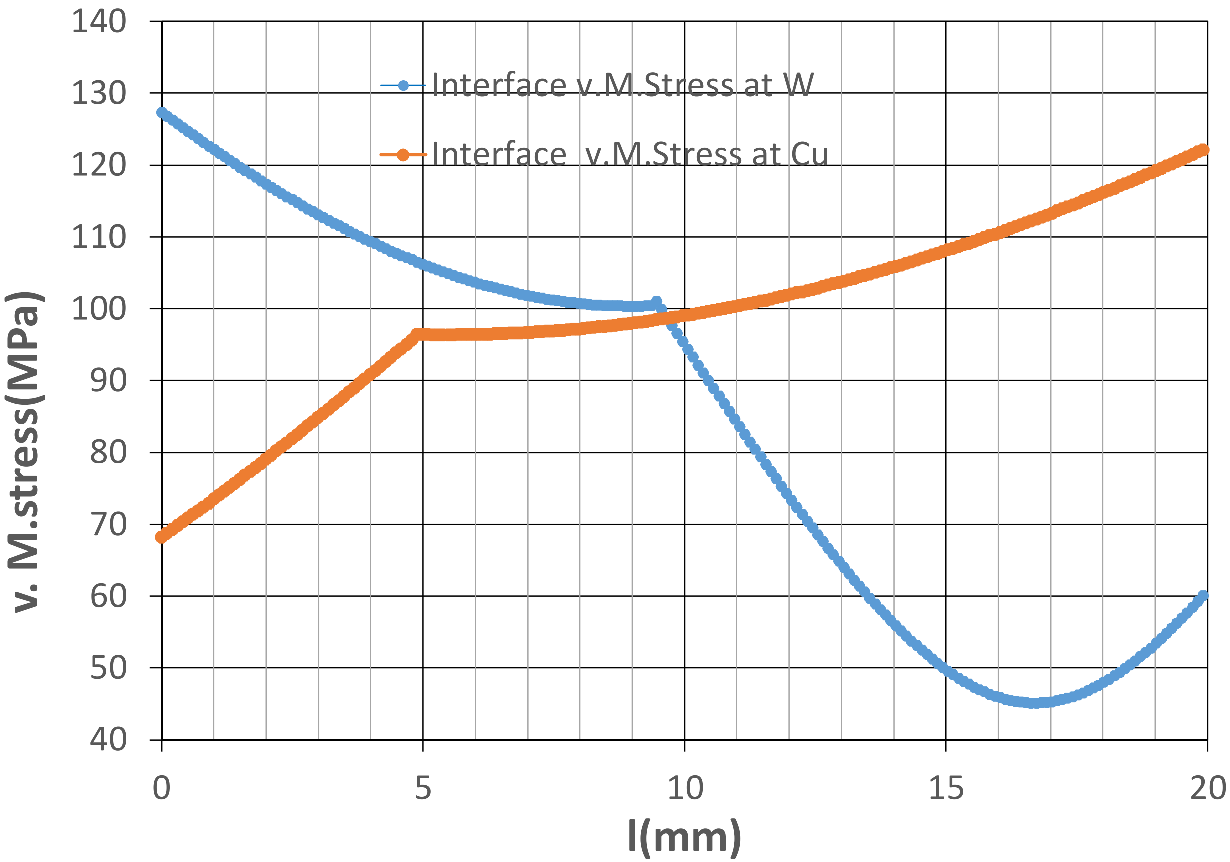
I: Copy of Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
Custom
Max: 251.18
Min: 0.56603
2017/1/18 10:20
251.18
223.33
195.48
167.64
139.79
111.95
84.102
56.257
28.412
0.56603
10mm
path
0.00
15.00
30.00 (mm)



interface
v. M.stress (MPa)
v.M.stress (Mpa)
l(mm)
100
95
90
85
80
75
70
65
60
0
5
10
15
20
25
30
35

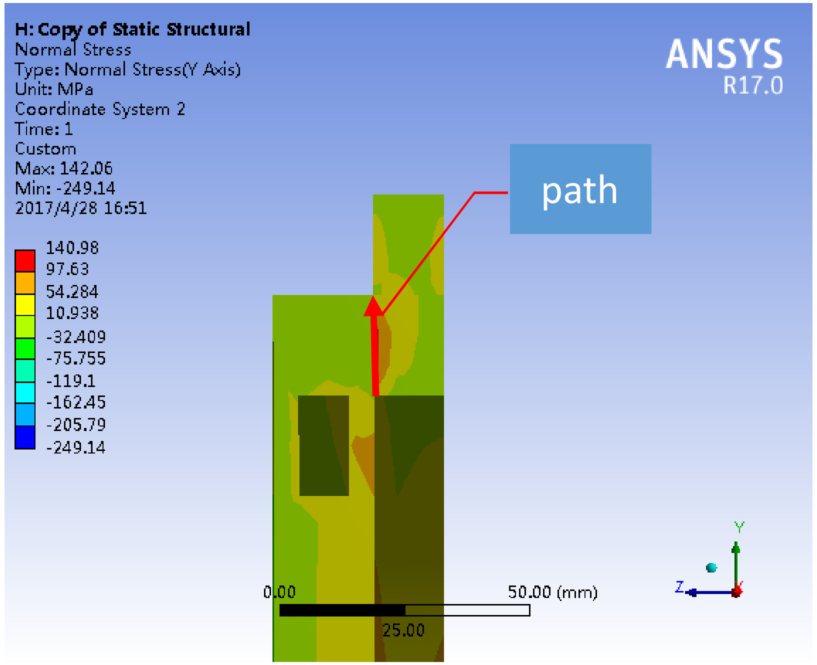
The v. M. stresses

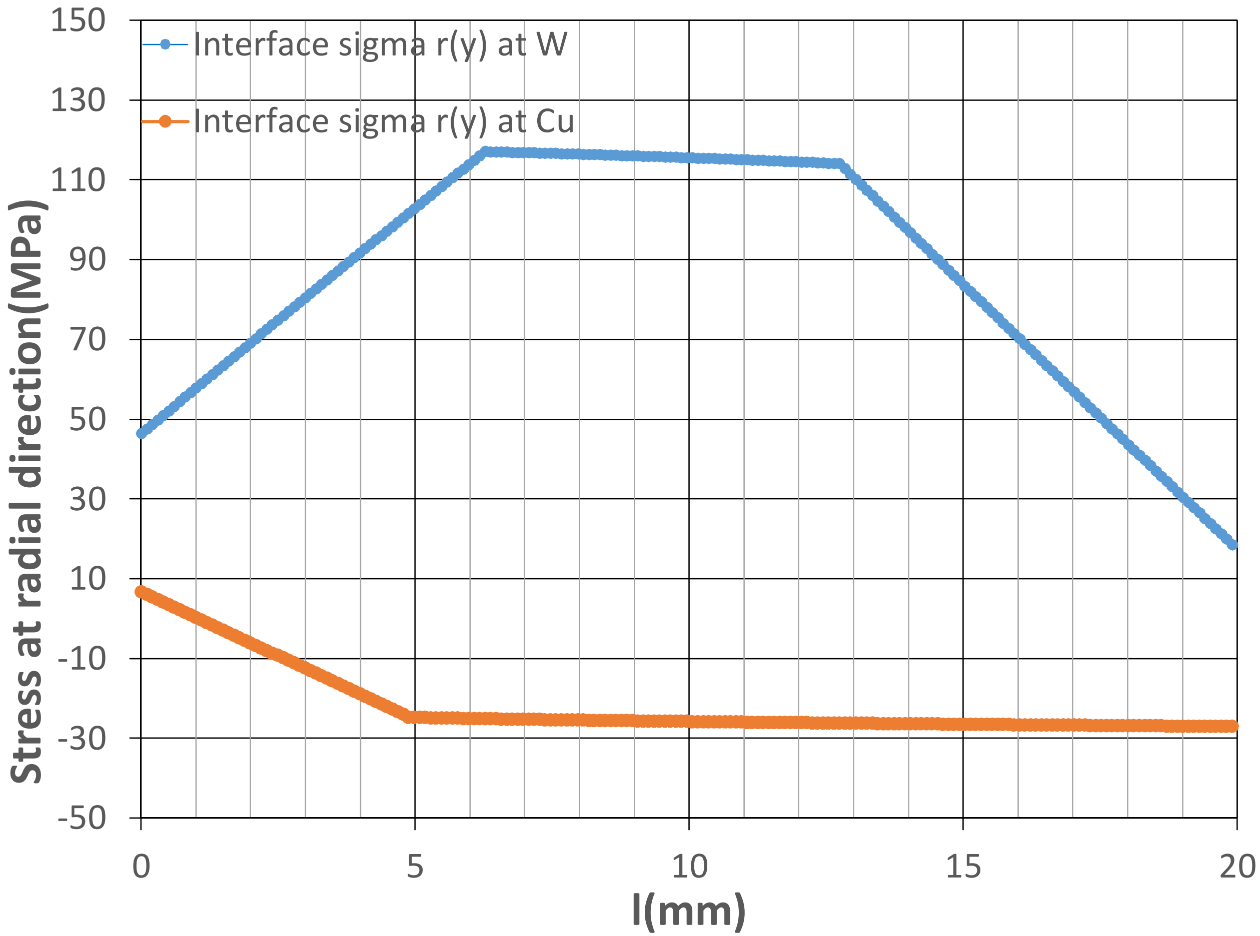




The v. M. stresses are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

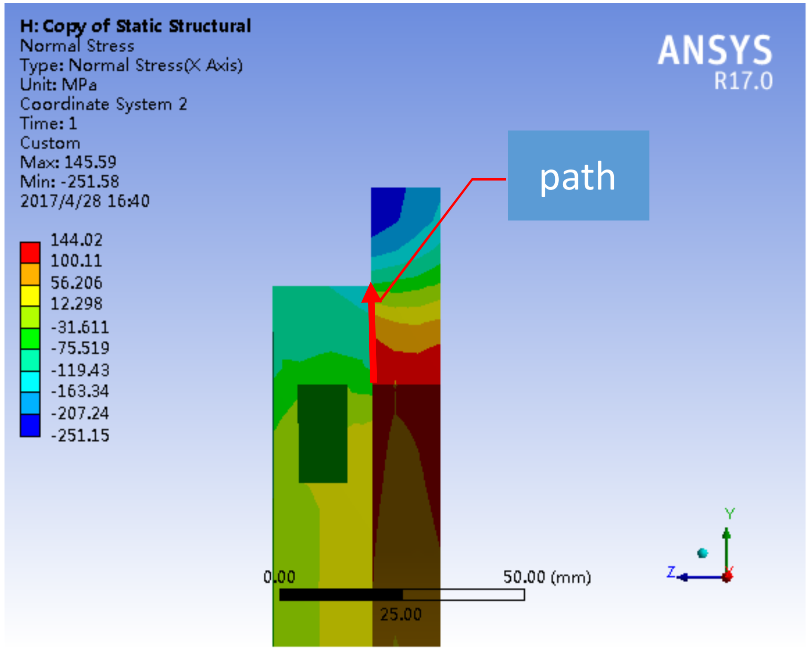
Sigma r

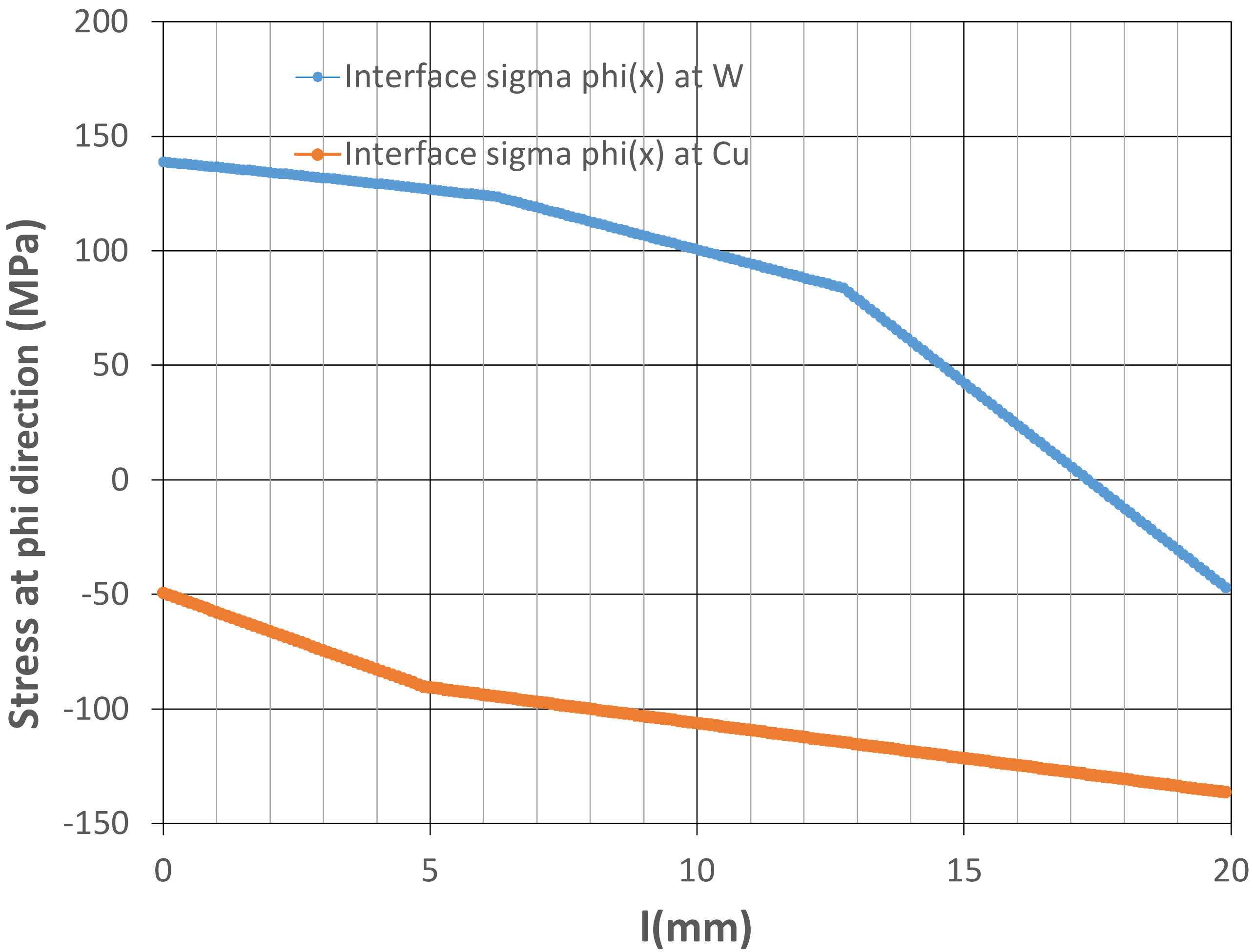




The stresses at radial direction are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

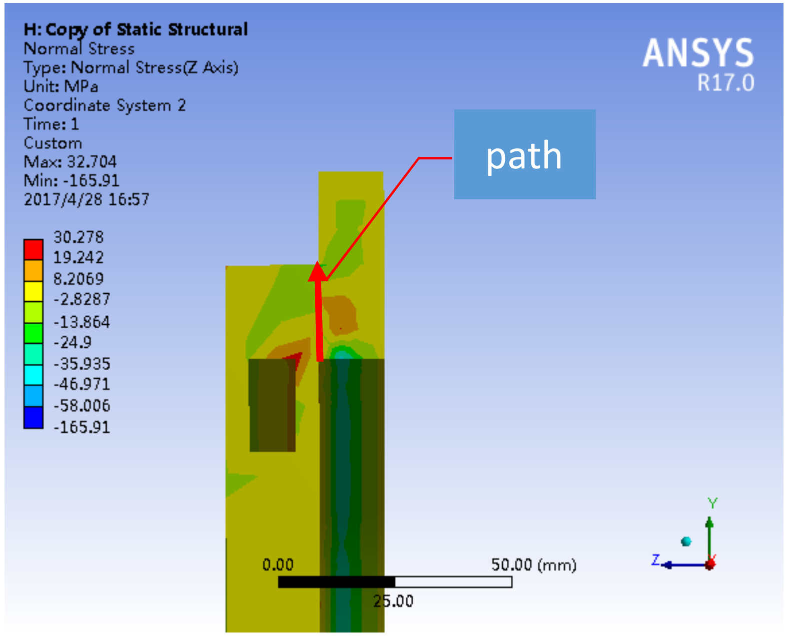
Sigma phi

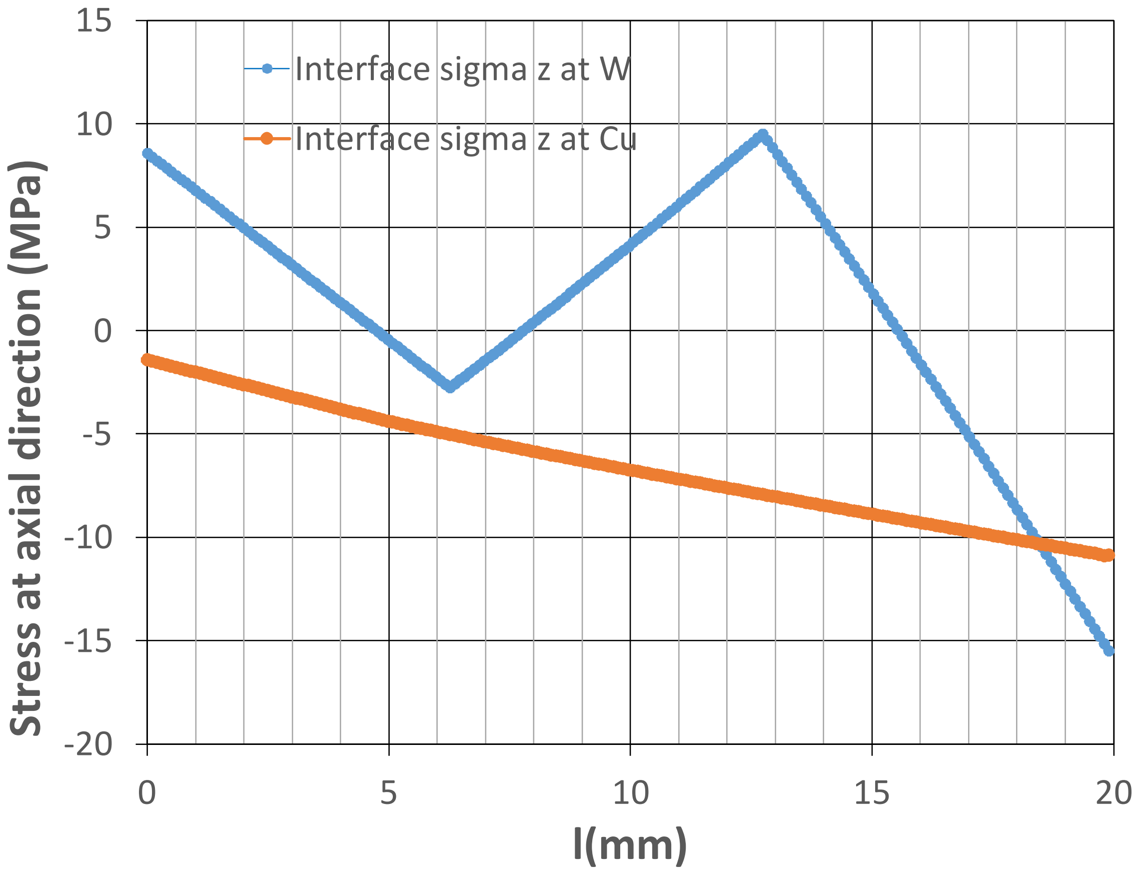




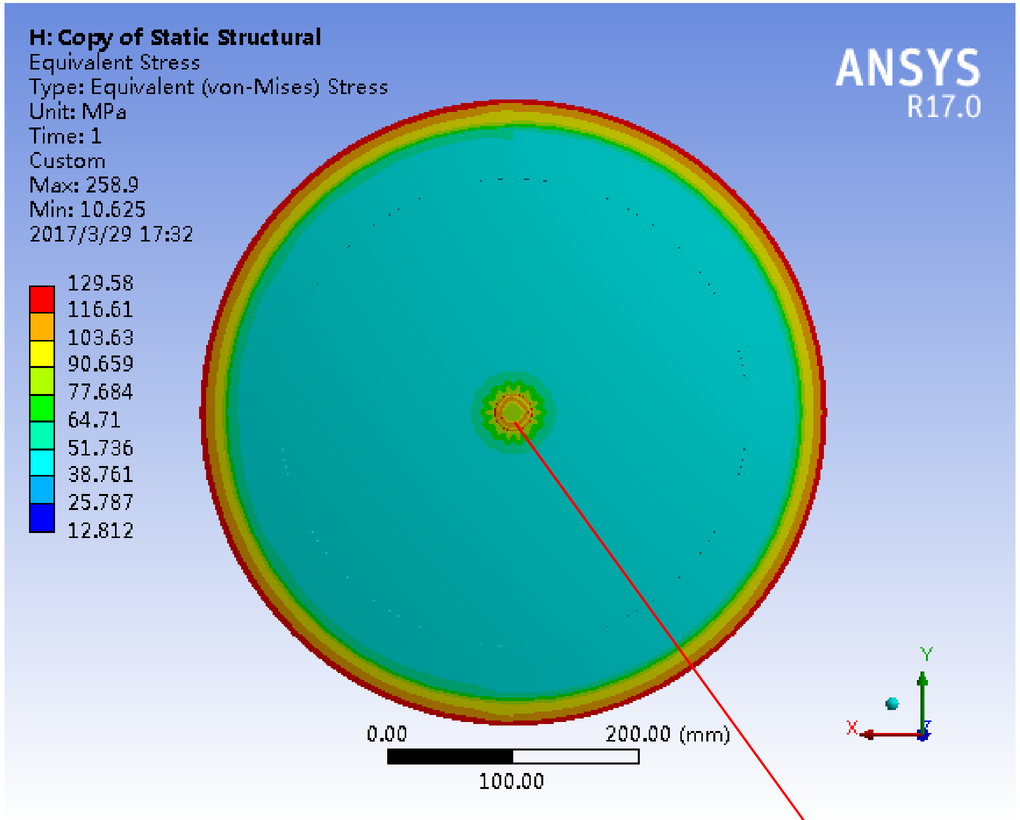
The stresses at phi direction are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

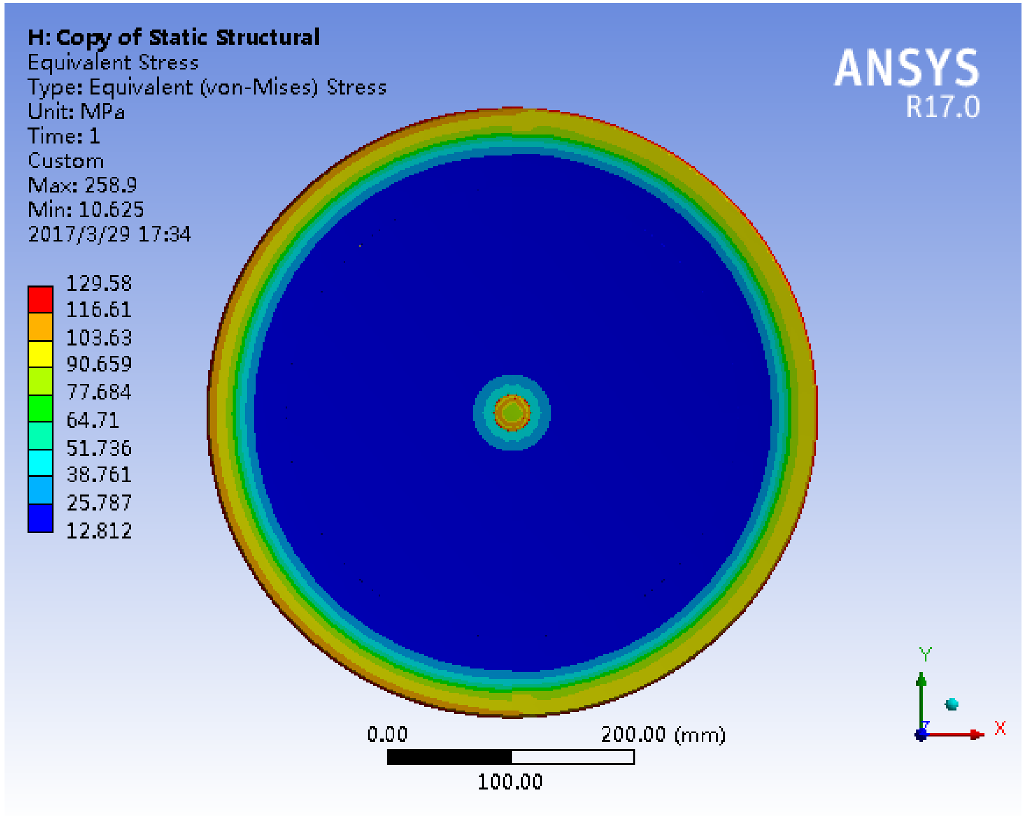
Sigma z





The stresses at axial direction are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.





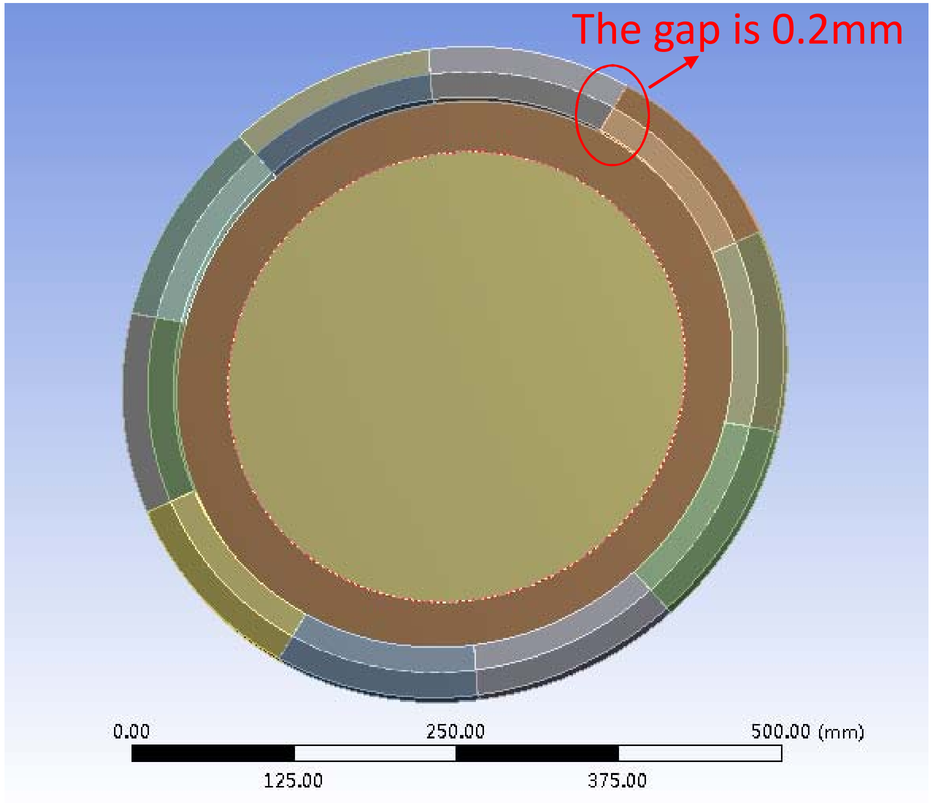
Stresses for Cu at interface.

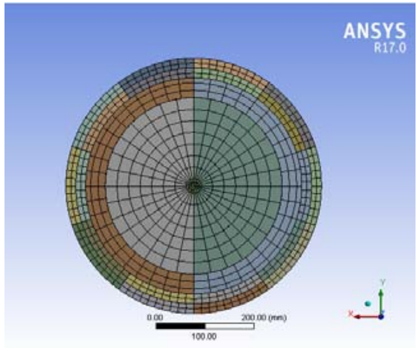
Stresses at the other side of Cu.

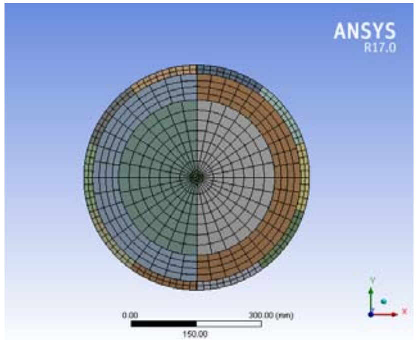
The Stress here should be because the center bar is fixed as a boundary condition.

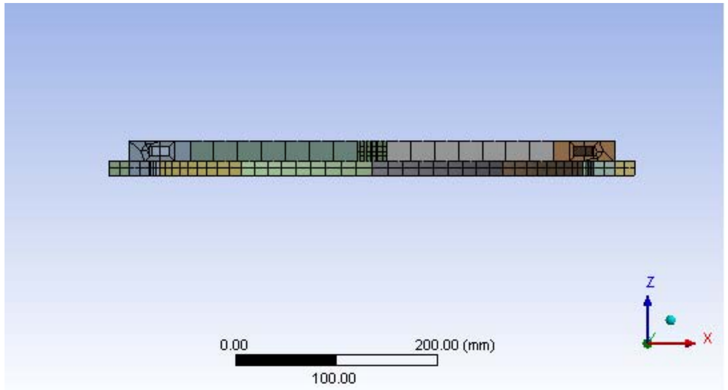
Model-2:
Sliced W-target with 10 gaps of 0.2mm

Model-2: sliced W-target with 10 gaps of 0.2mm

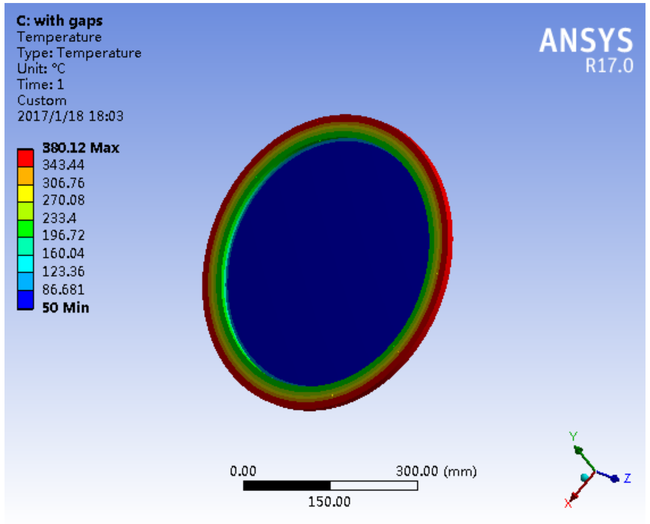


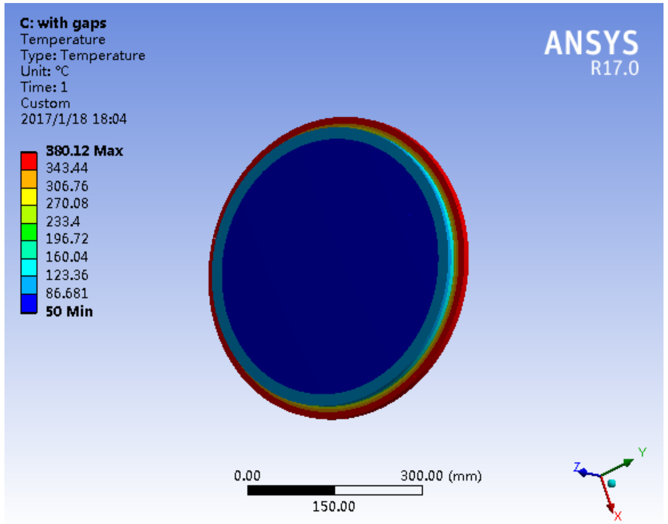


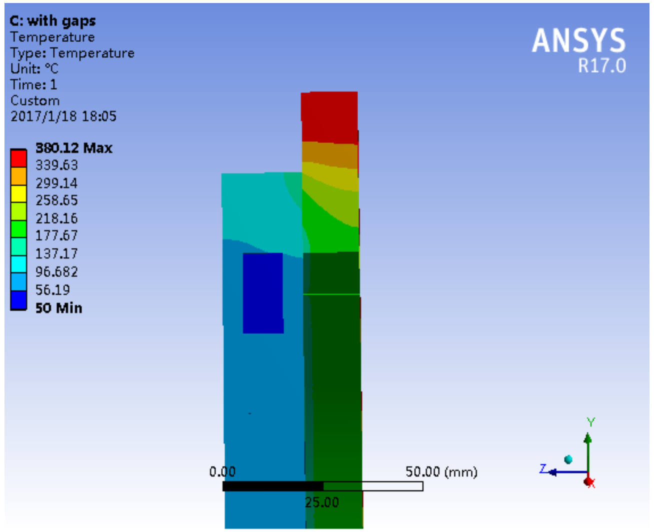




Results: Temperature distribution

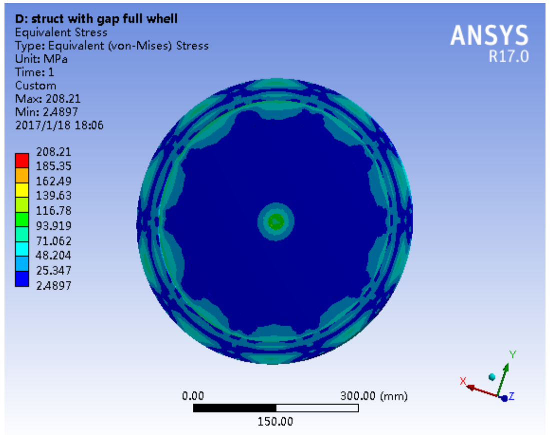


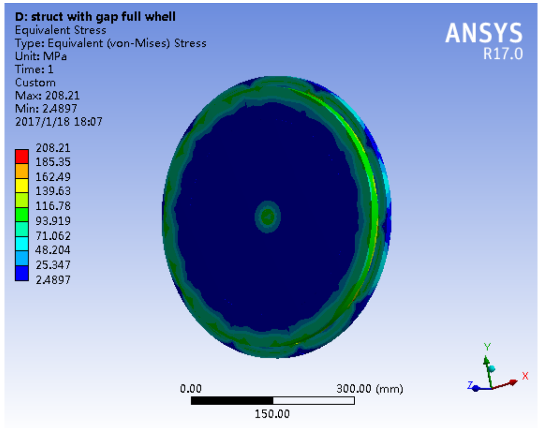


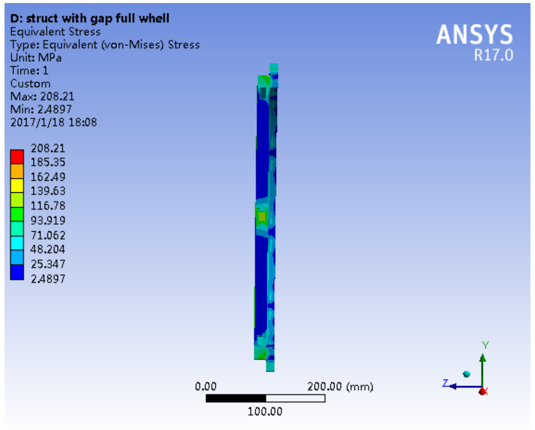


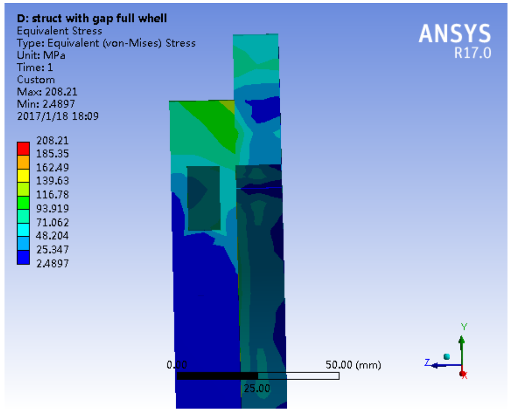
They are essentially the same as in the full ring, as expected.

Results: Stresses

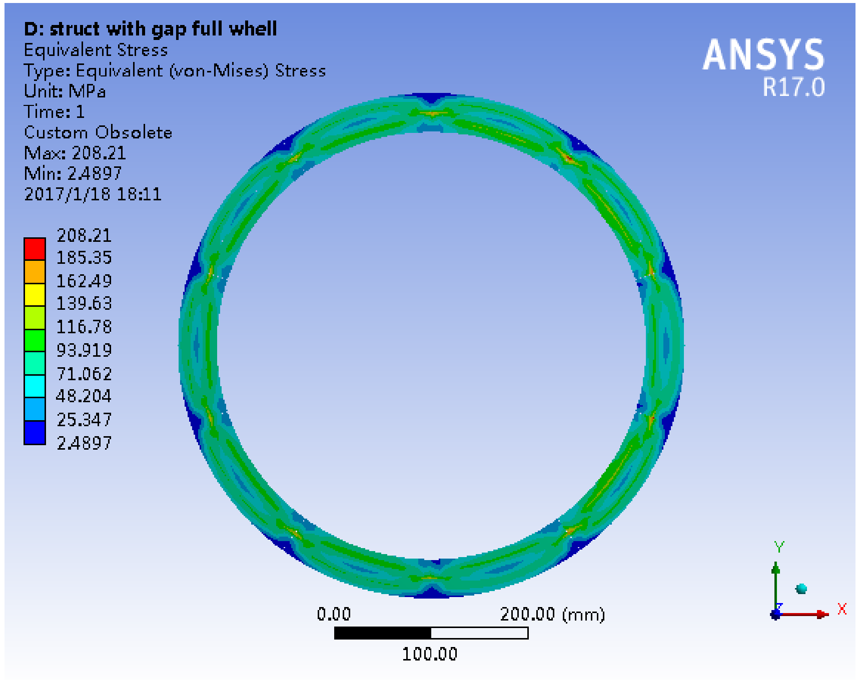




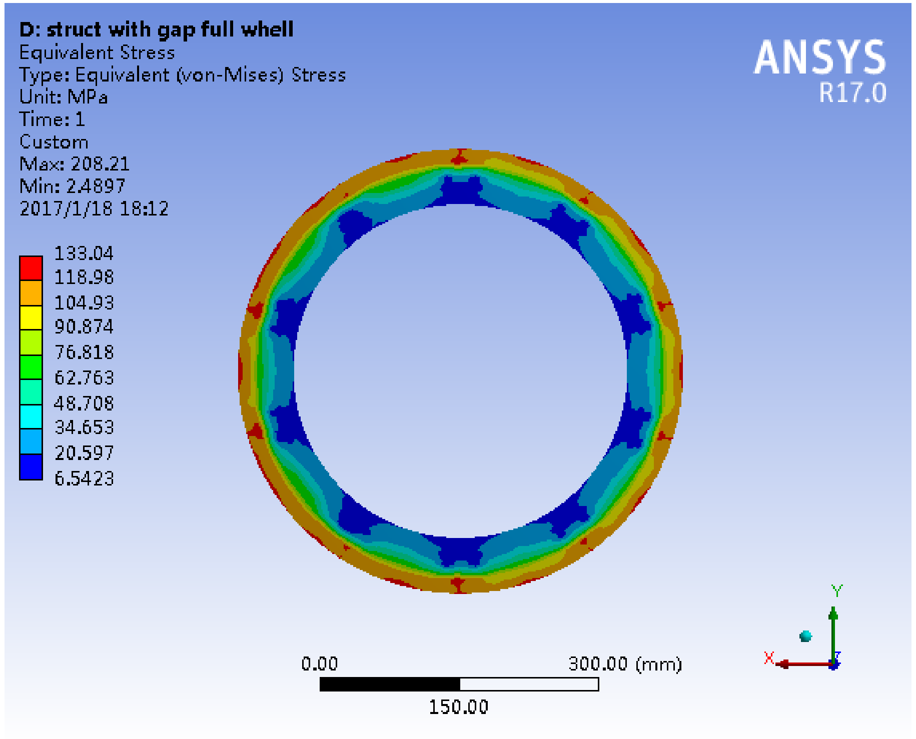




v. M. Stresses distribution at interface

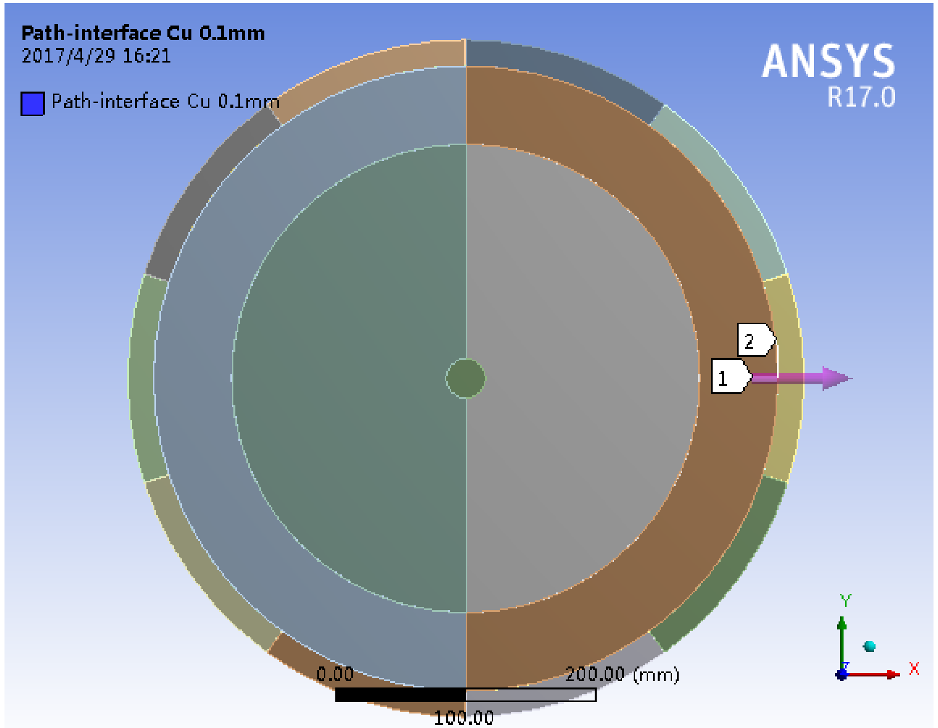


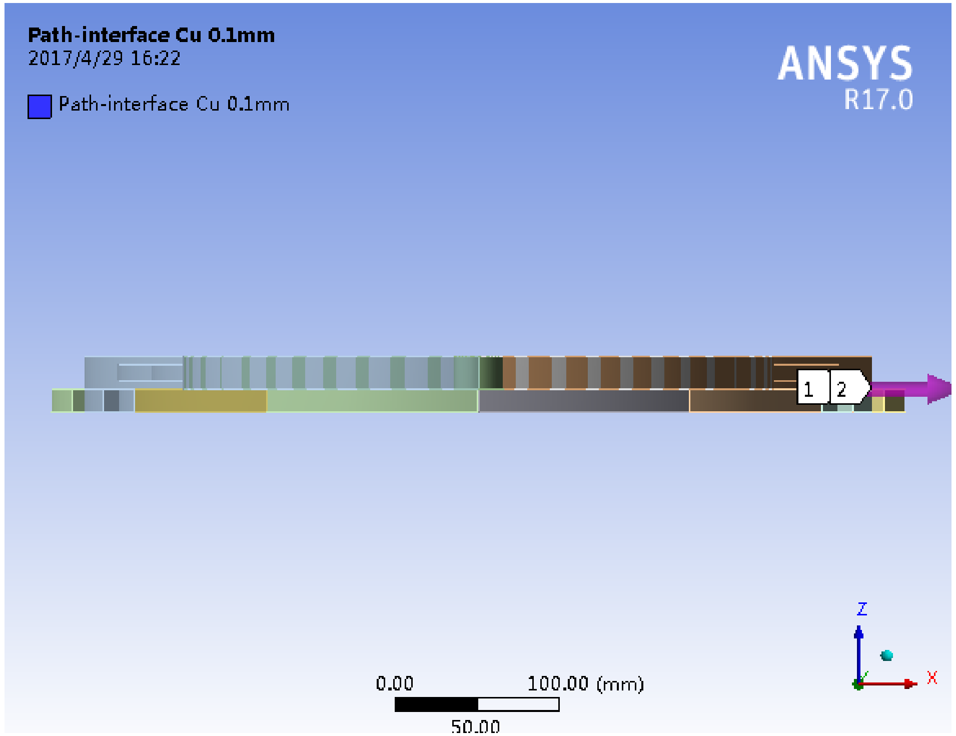
v. M. stress in-plane of contact surface at W wheel



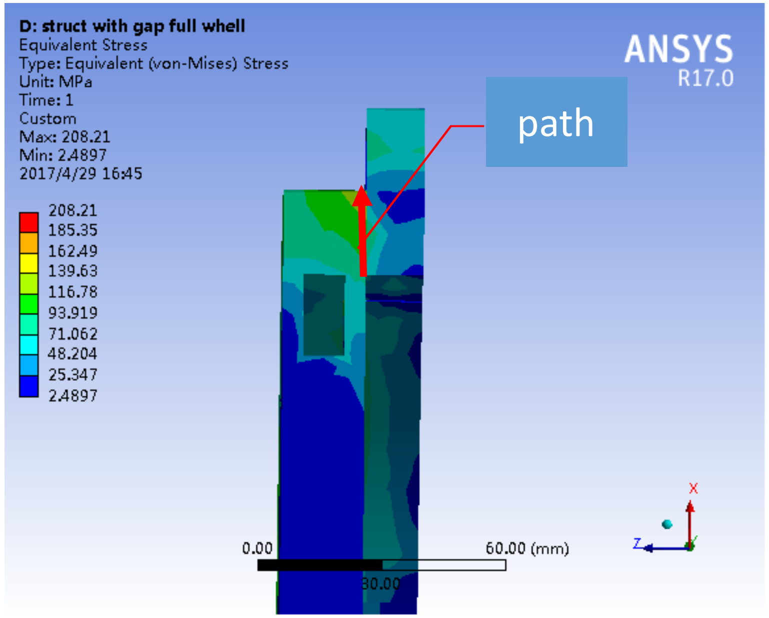
v. M. stress in-plane of contact surface at Cu wheel

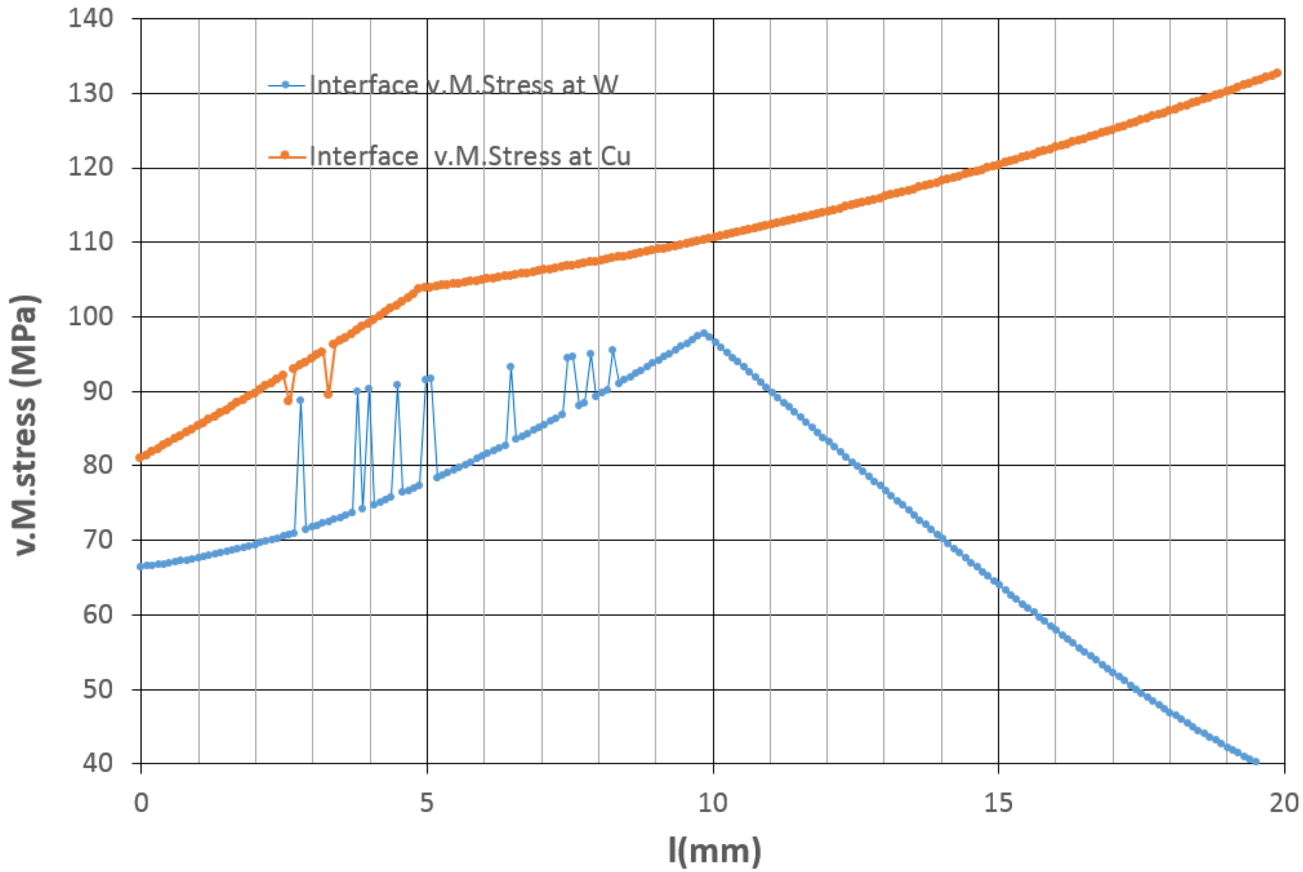
Stresses at center of the sector





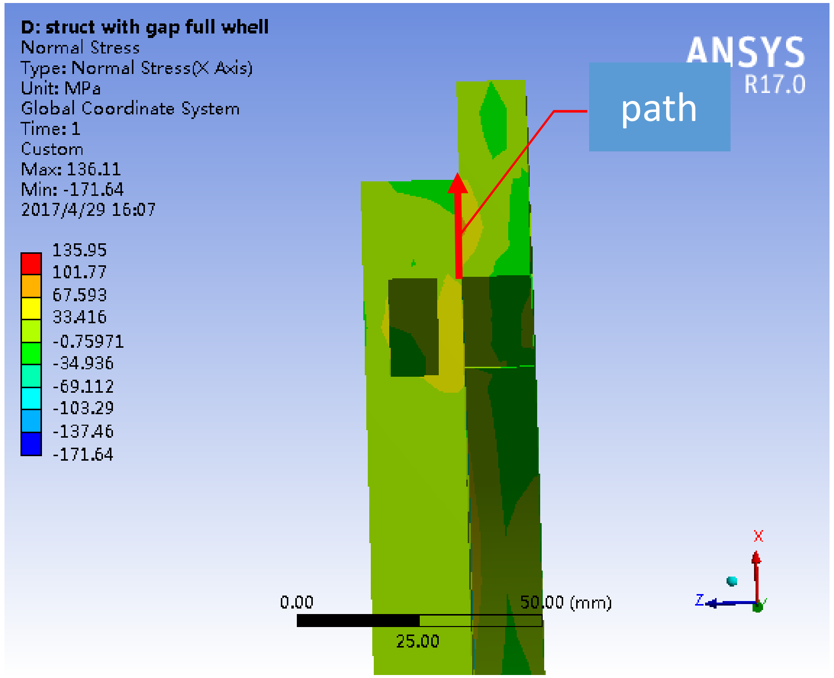
The v. M. stresses

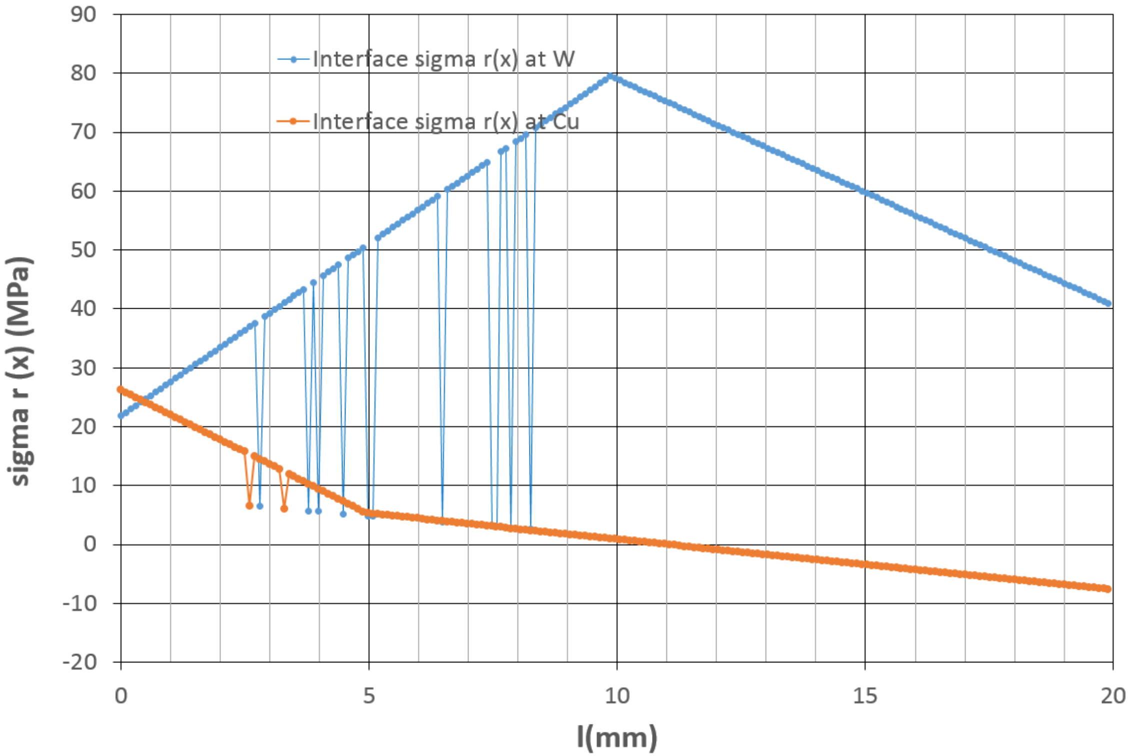




- The v. M. stresses are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.
- There a binning problem. It should not be a real data.

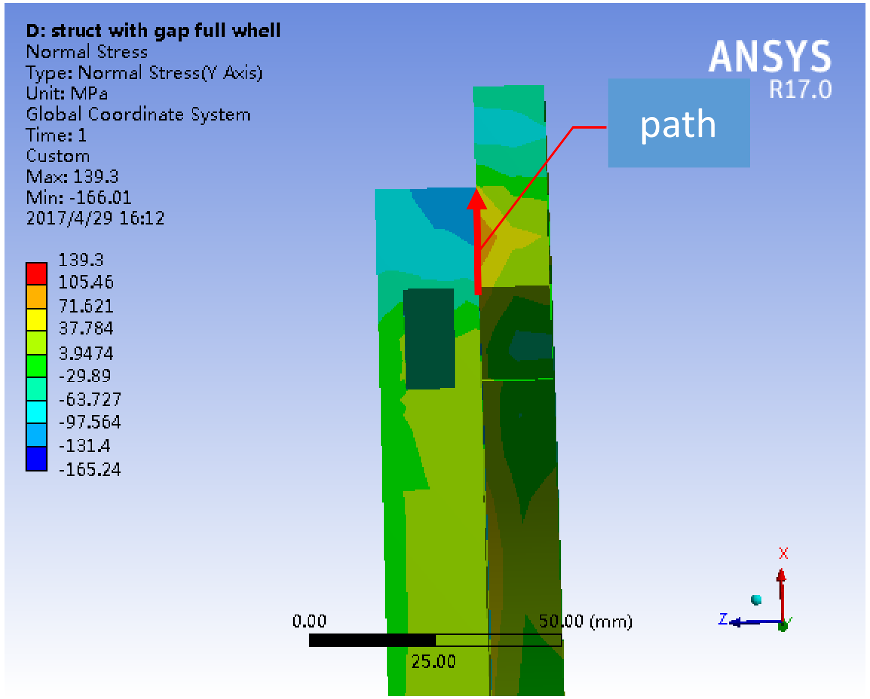
Sigma r

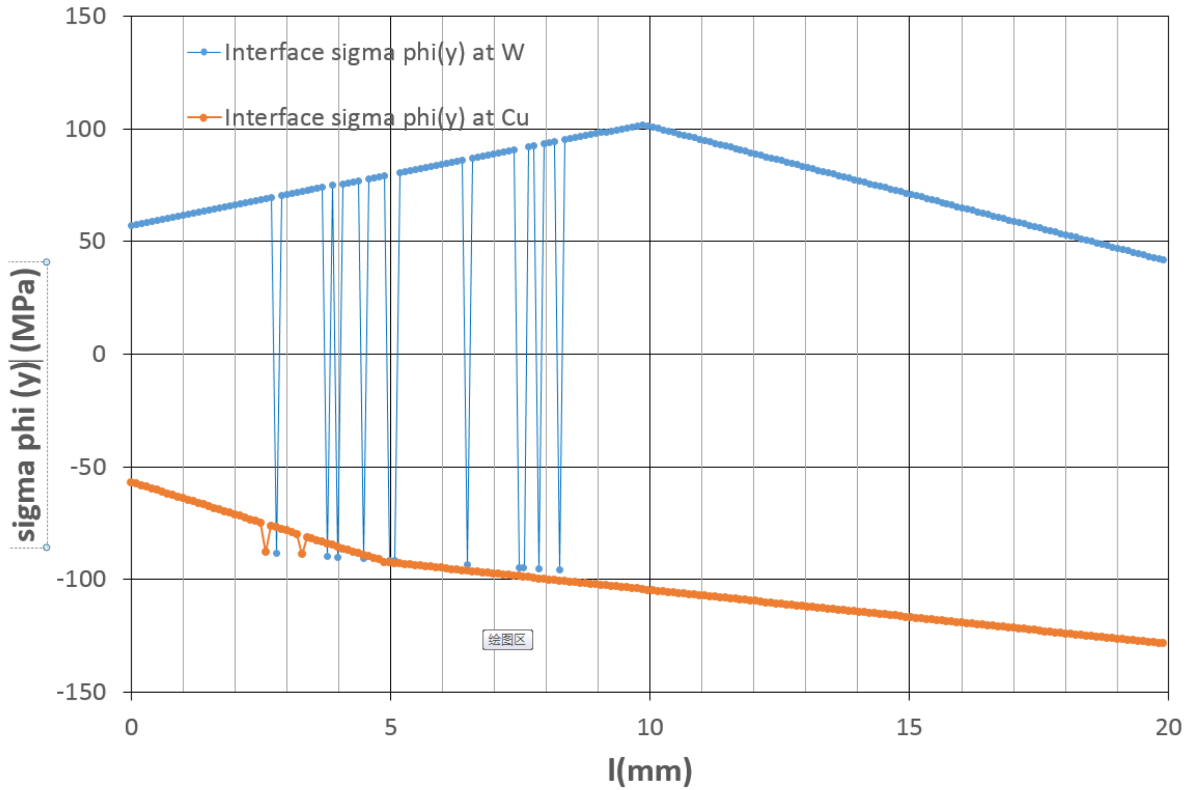




The stresses at radial direction (sigma x) are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

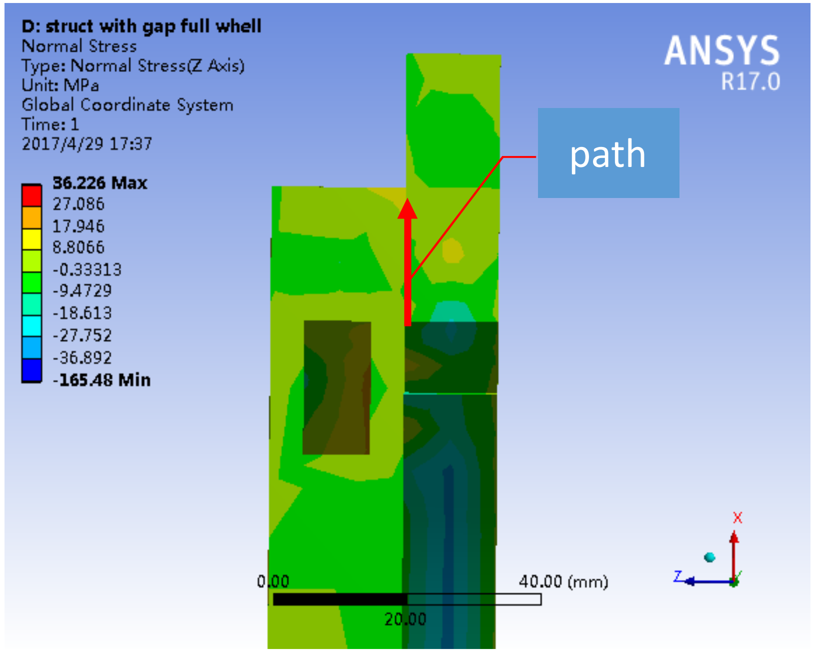
Sigma phi

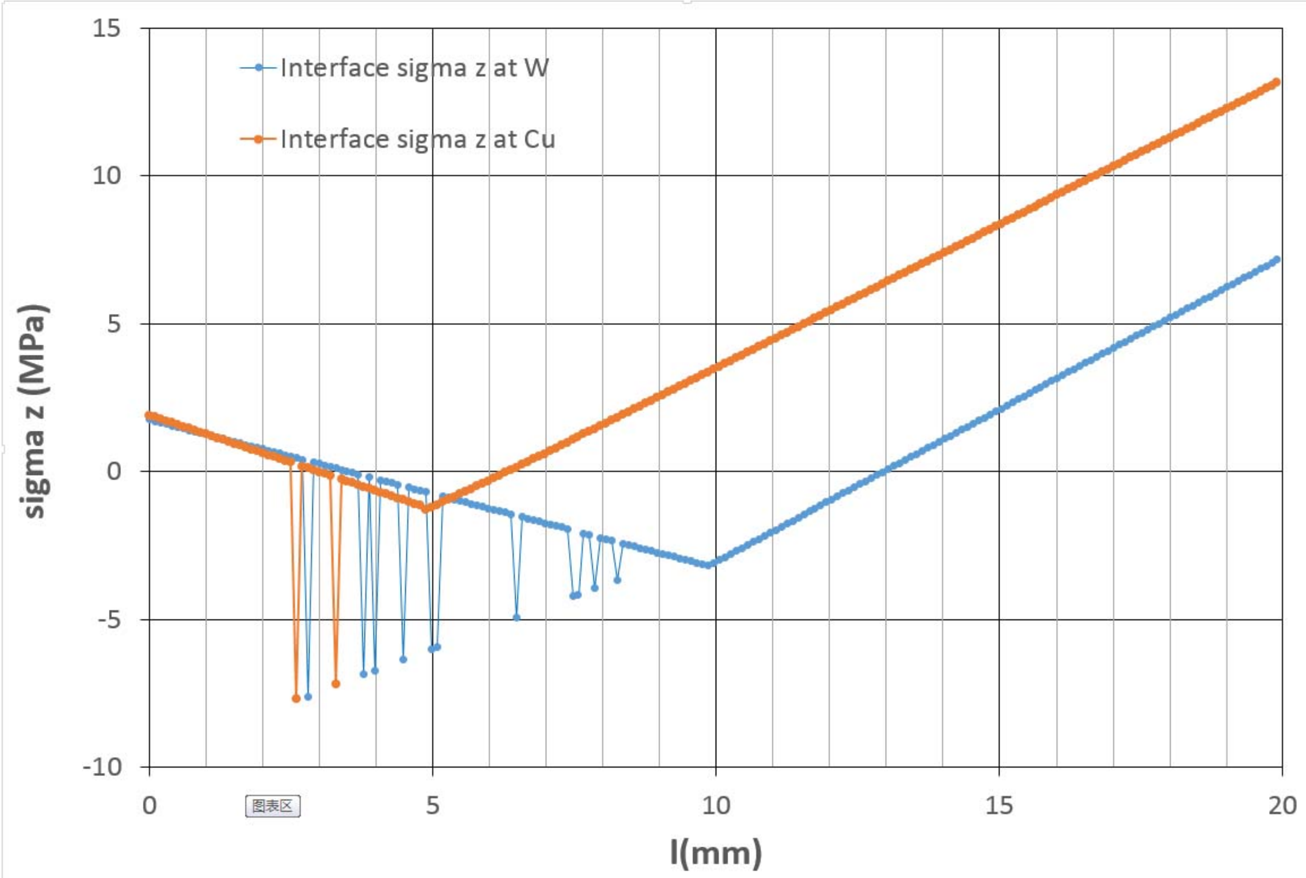




The stresses at phi direction are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

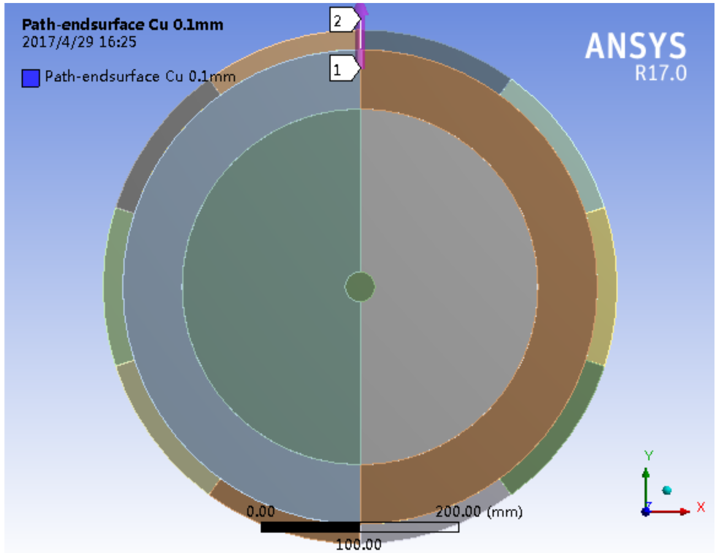
Sigma z

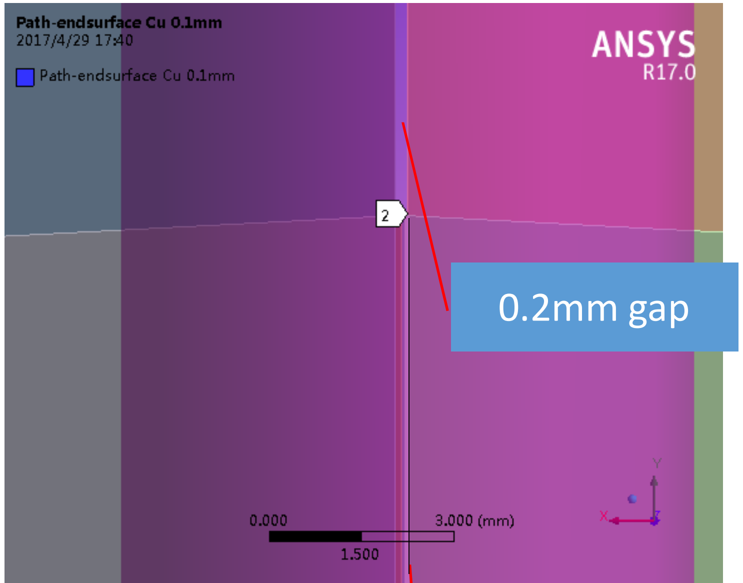


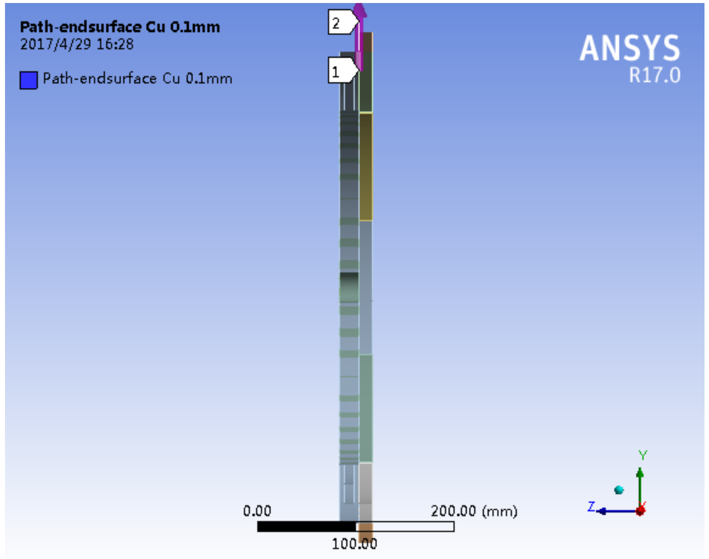


The stresses at axial direction are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

Stresses at end of the sector



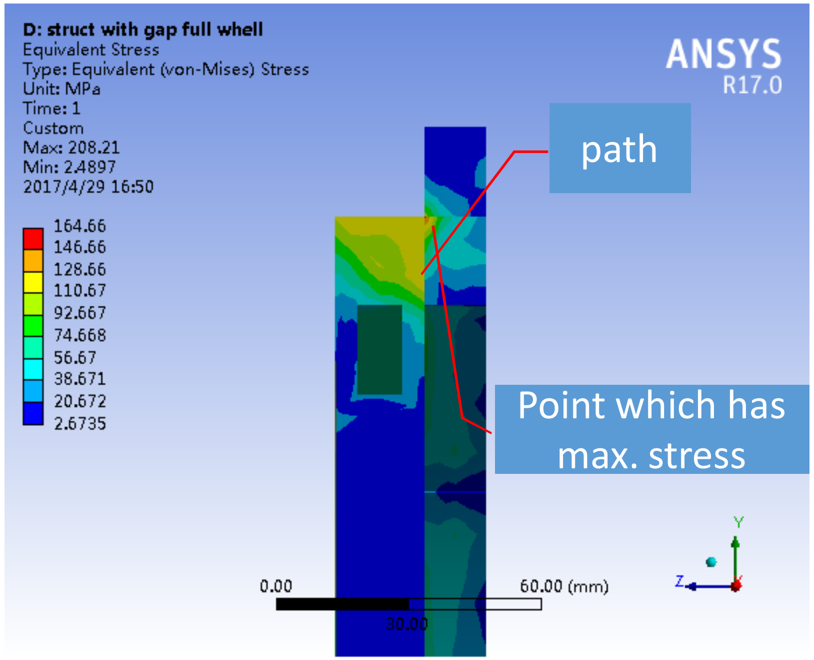


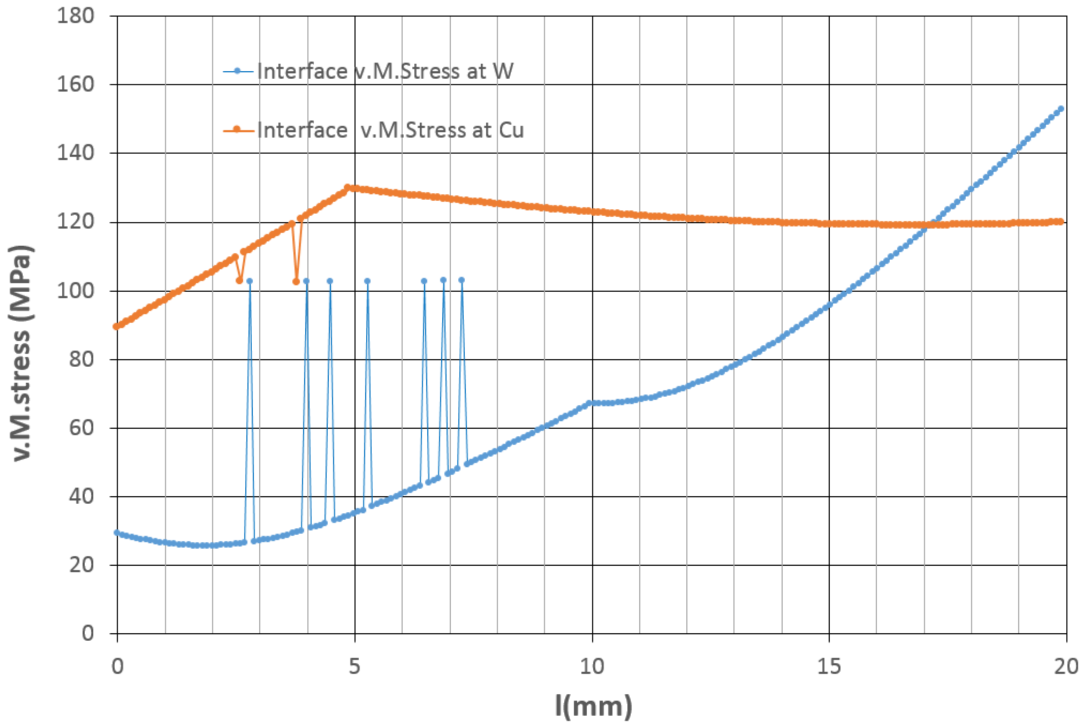


0.2mm gap

Path for W is on the surface of W due to gaps

The v. M. stresses

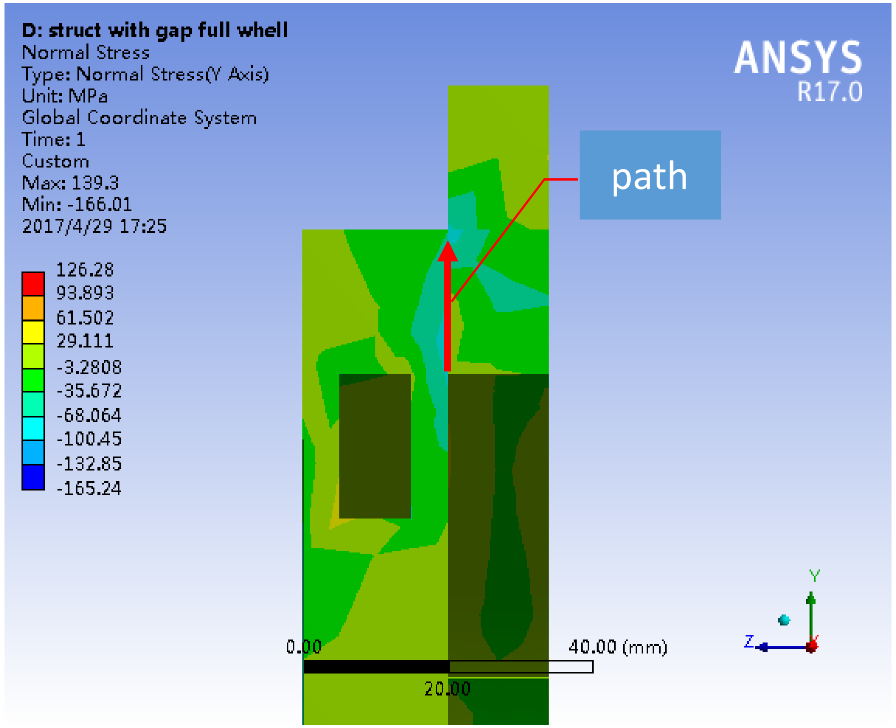


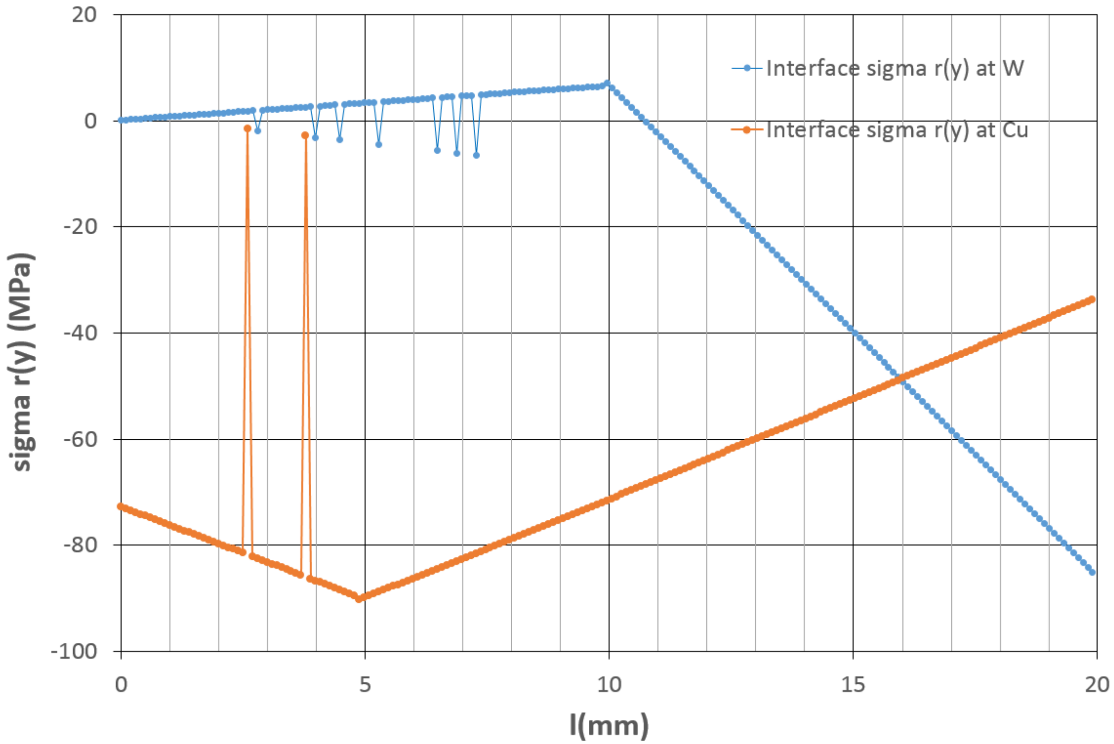


- The v. M. stresses are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.
- Path for W is on the surface of W due to the gaps.
- Discussion: the max. stress in this picture appearing at the point shown in the picture is about 164Mpa. However, the max. stress for whole model is about 208MPa. It appears at the similar point in one of connection positions between gaps and Cu cooler.

k

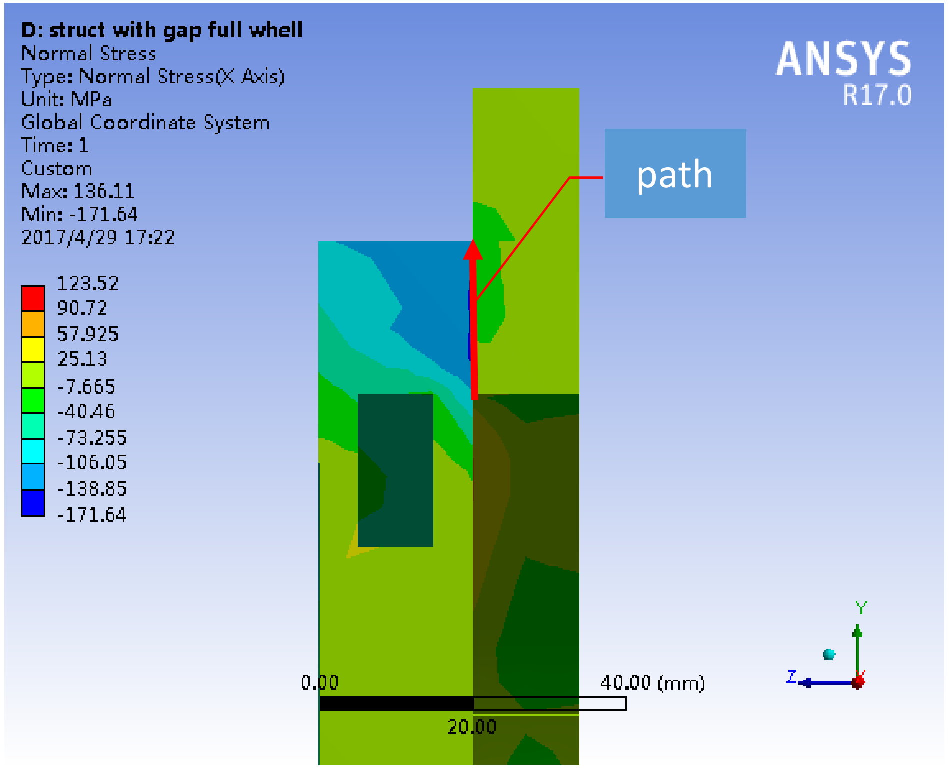
Sigma r

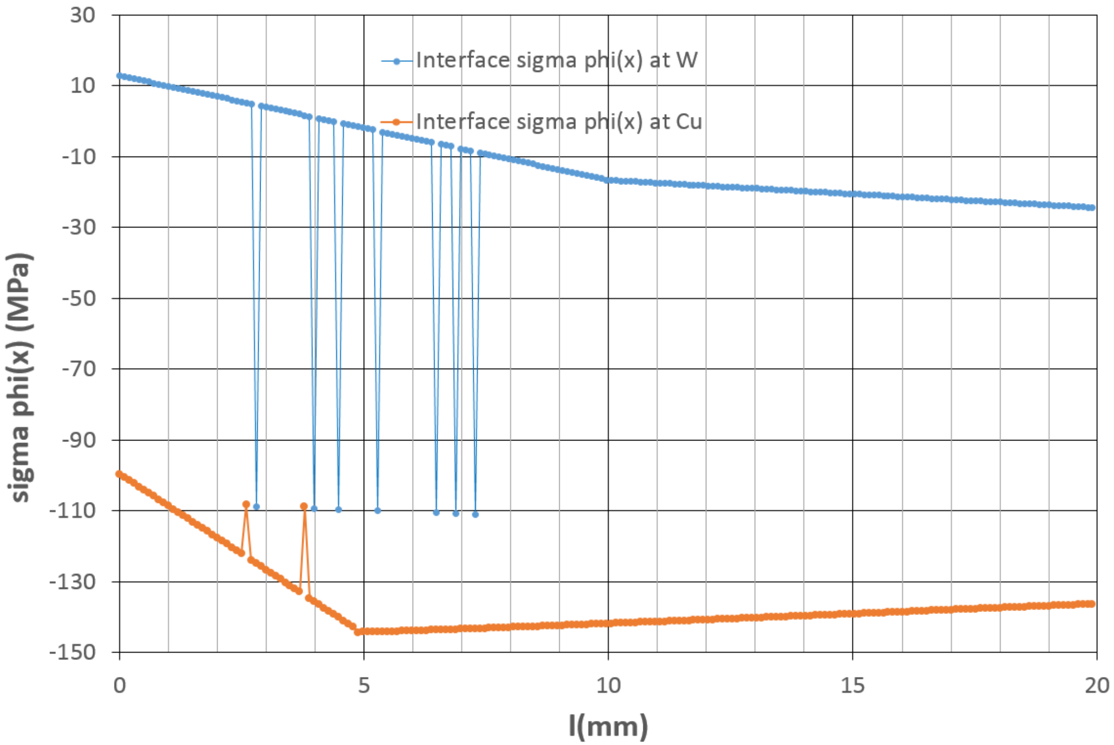




The stresses at radial direction are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

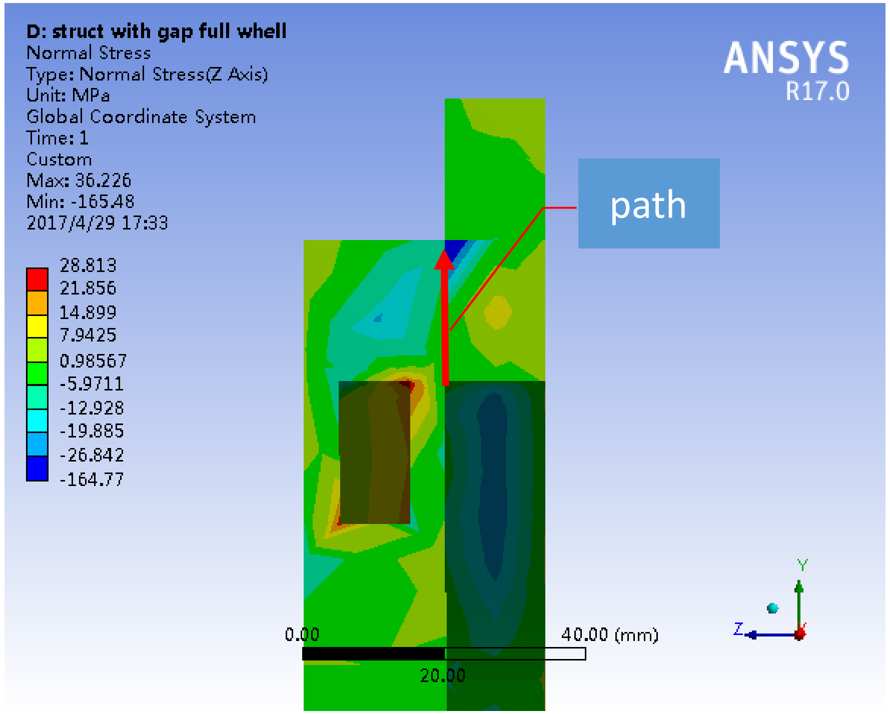
Sigma phi

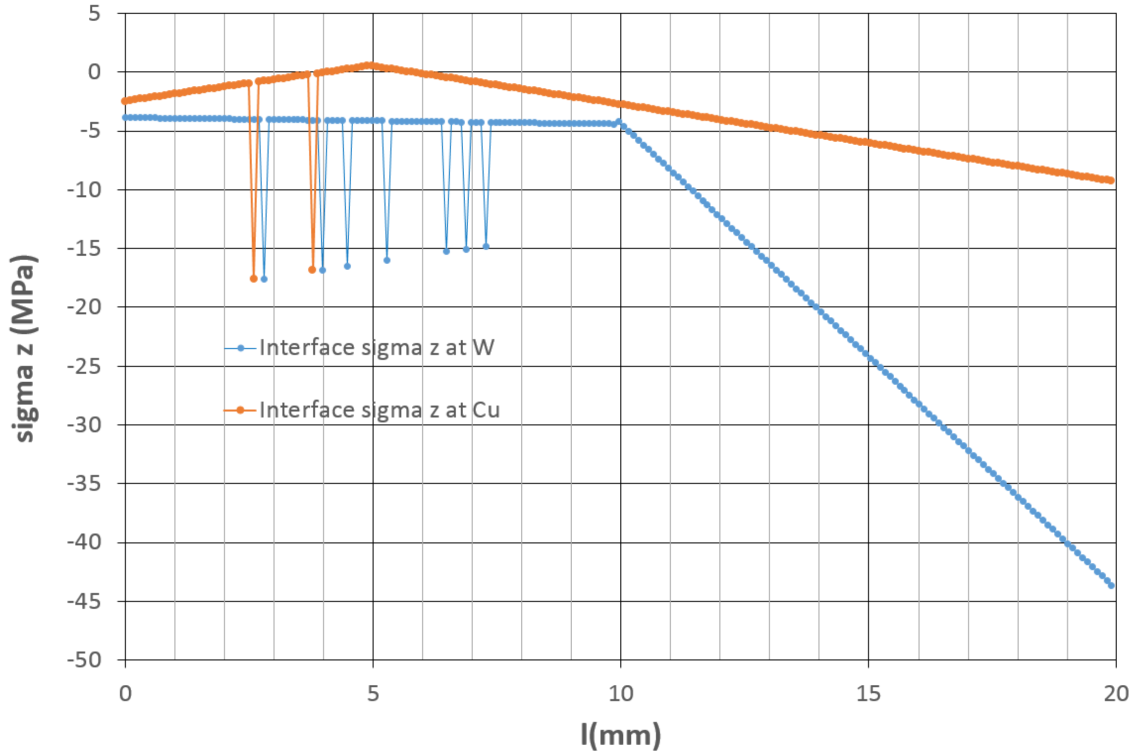




The stresses at phi direction are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

Sigma z

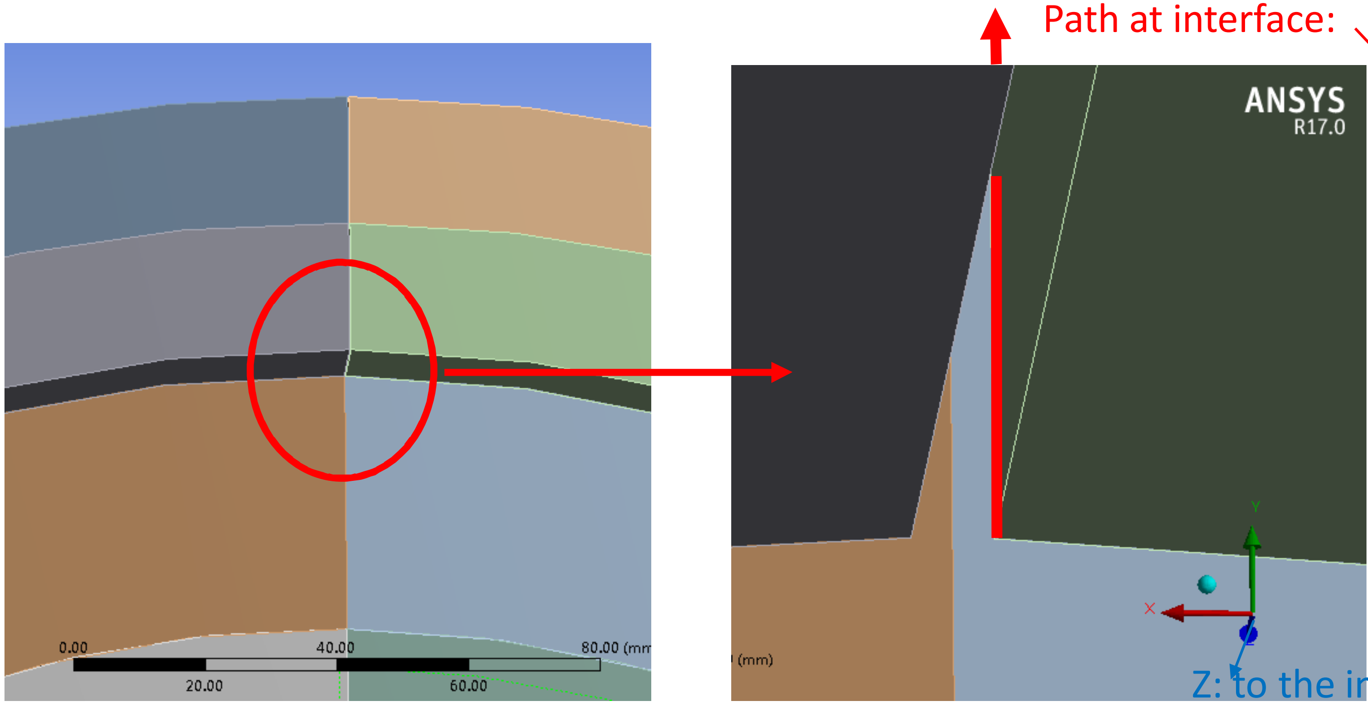




The stresses at axial direction are obtained at the surfaces which are both 0.1mm off the interface for Cu and W.

Stresses check near the interface at end of the sector

- Model: it is the same as model-2
- The v. M. stresses at end-surface are calculation near the interface at end of sector



Path at interface:

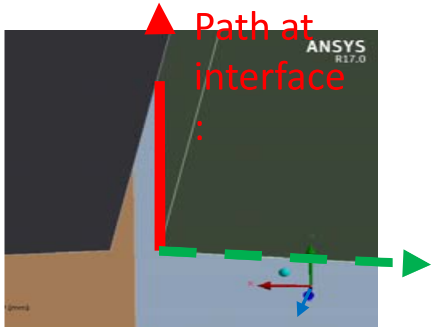
Path(x,y,z /mm)= (-0.1, 220, -20) to (-0.1, 240, -20)

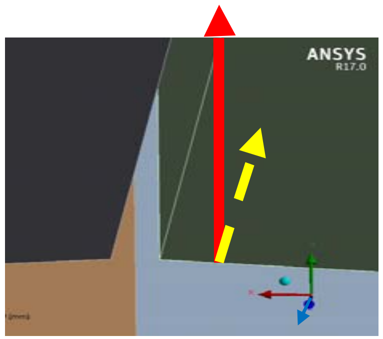
Z: to the inside of paper

So, we check the paths as following:

W:
(-0.2, 220, -20.1) to (-0.2, 240, -20.1)
(-0.4, 220, -20.1) to (-0.4, 240, -20.1)
(-0.6, 220, -20.1) to (-0.6, 240, -20.1)
(-0.8, 220, -20.1) to (-0.8, 240, -20.1)
(-1.0, 220, -20.1) to (-1.0, 240, -20.1)
Cu
(-0.2, 220, - 19.9) to (-0.2, 240, - 19.9)
(-0.4, 220, - 19.9) to (-0.4, 240, - 19.9)
(-0.6, 220, - 19.9) to (-0.6, 240, - 19.9)
(-0.8, 220, - 19.9) to (-0.8, 240, - 19.9)
(-1.0, 220, - 19.9) to (-1.0, 240, - 19.9)

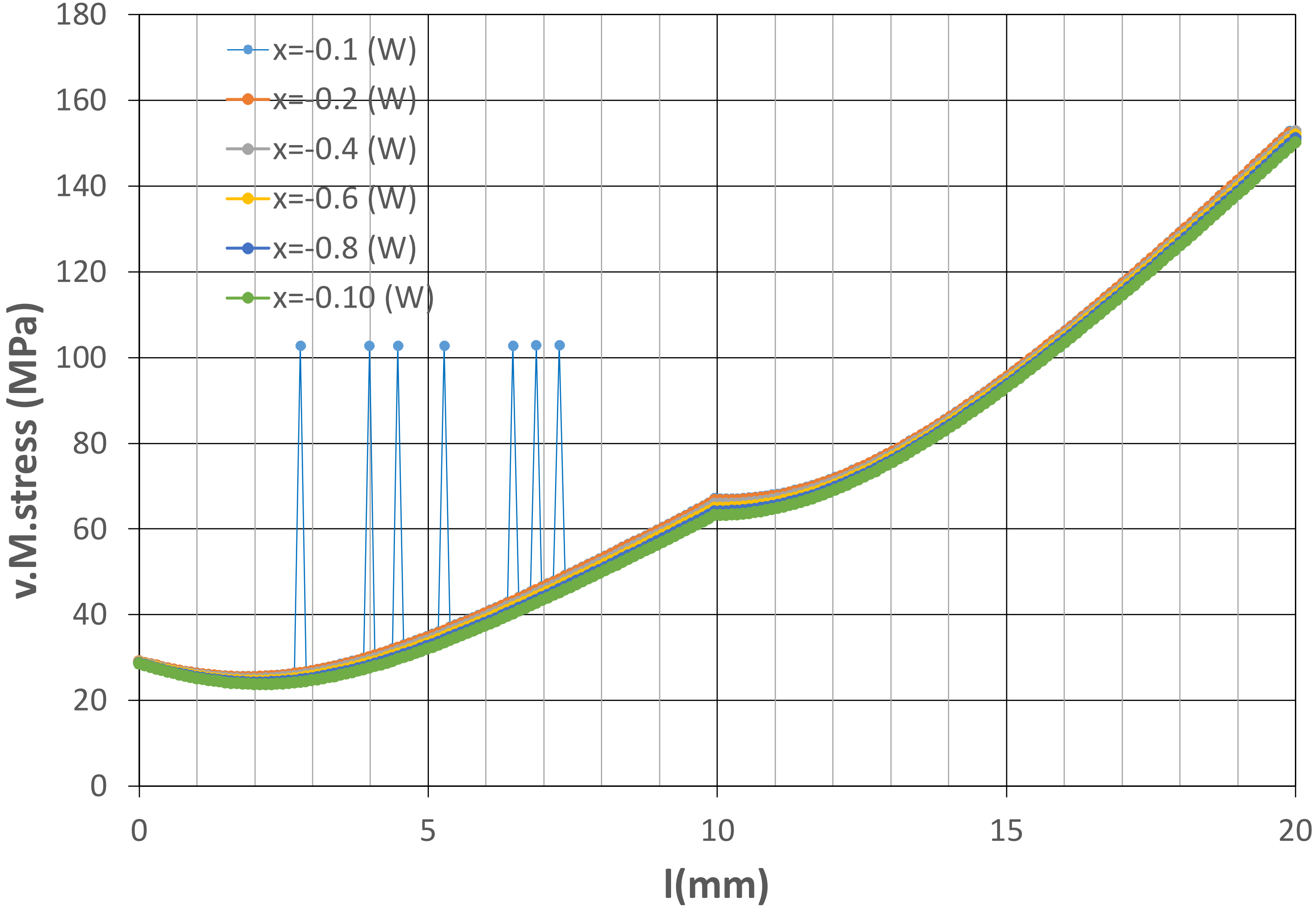
W:
(-1.0, 220, -20.2) to (-1.0, 240, -20.2)
(-1.0, 220, -20.4) to (-1.0, 240, -20.4)
(-1.0, 220, -20.6) to (-1.0, 240, -20.6)
(-1.0, 220, -20.8) to (-1.0, 240, -20.8)
(-1.0, 220, -21) to (-1.0, 240, -21)
Cu
(-1.0, 220, - 19.8) to (-1.0, 240, - 19.8)
(-1.0, 220, - 19.6) to (-1.0, 240, - 19.6)
(-1.0, 220, - 19.4) to (-1.0, 240, - 19.4)
(-1.0, 220, - 19.2) to (-1.0, 240, - 19.2)
(-1.0, 220, - 18) to (-1.0, 240, - 18)





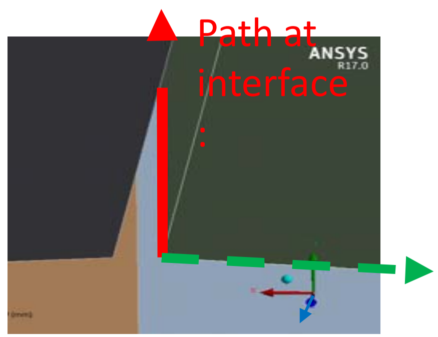
Path at
interface
:

v. M. stress for W

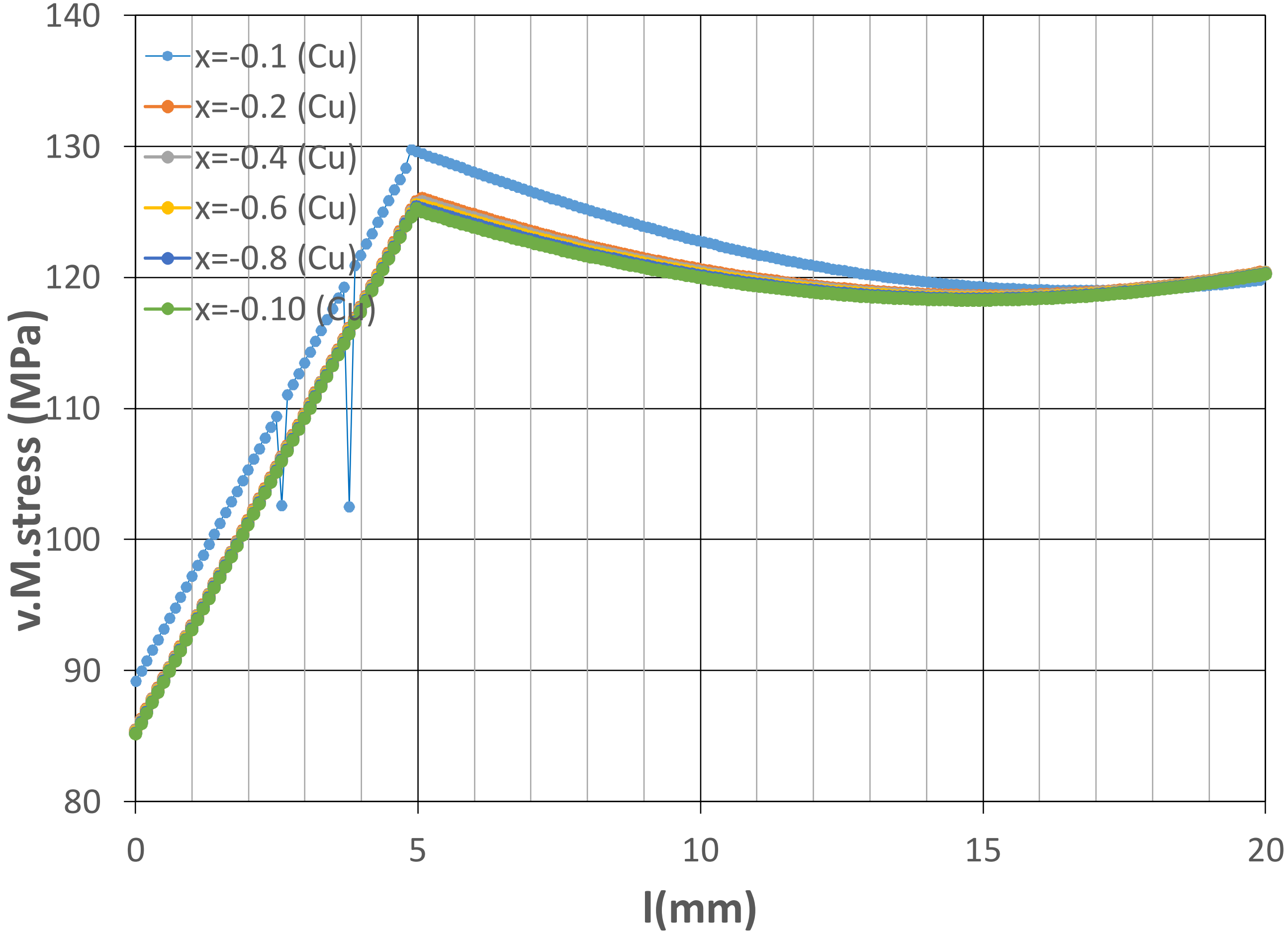


W:
(-0.2, 220, -20.1) to (-0.2, 240, -20.1)
(-0.4, 220, -20.1) to (-0.4, 240, -20.1)
(-0.6, 220, -20.1) to (-0.6, 240, -20.1)
(-0.8, 220, -20.1) to (-0.8, 240, -20.1)
(-1.0, 220, -20.1) to (-01.0, 240, -20.1)

Along the interface at tungsten

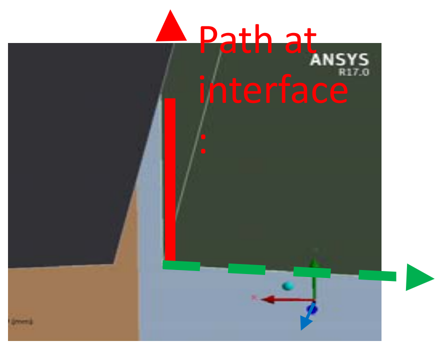


v. M. stress for Cu

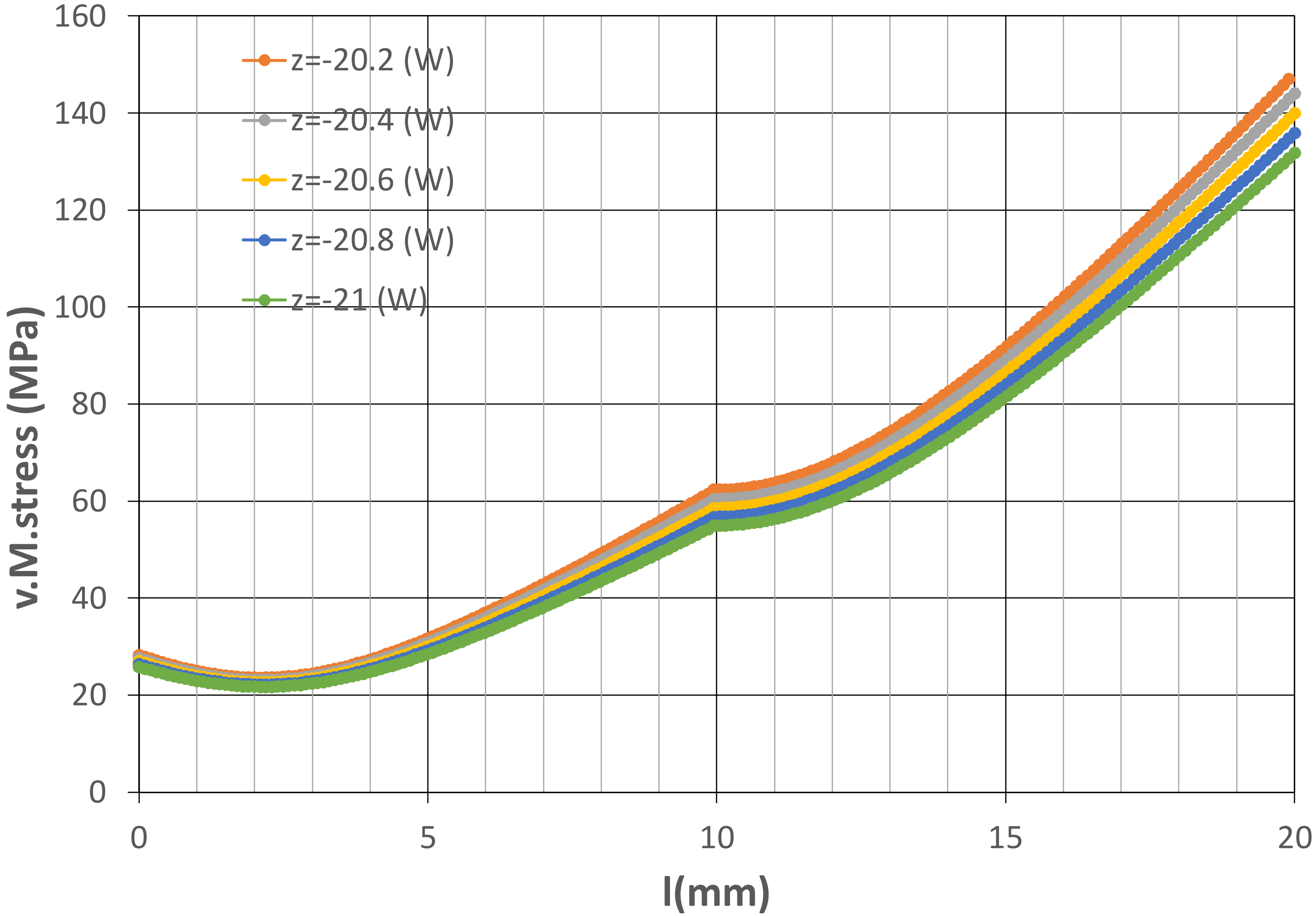


Cu
(-0.2, 220, - 19.9) to (-0.2, 240, - 19.9)
(-0.4, 220, - 19.9) to (-0.4, 240, - 19.9)
(-0.6, 220, - 19.9) to (-0.6, 240, - 19.9)
(-0.8, 220, - 20.1) to (-0.8, 240, - 19.9)
(-1.0, 220, - 19.9) to (-1.0, 240, - 19.9)

Along the interface at Cu



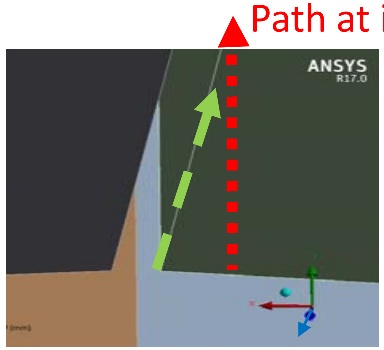
v. M. stress for W



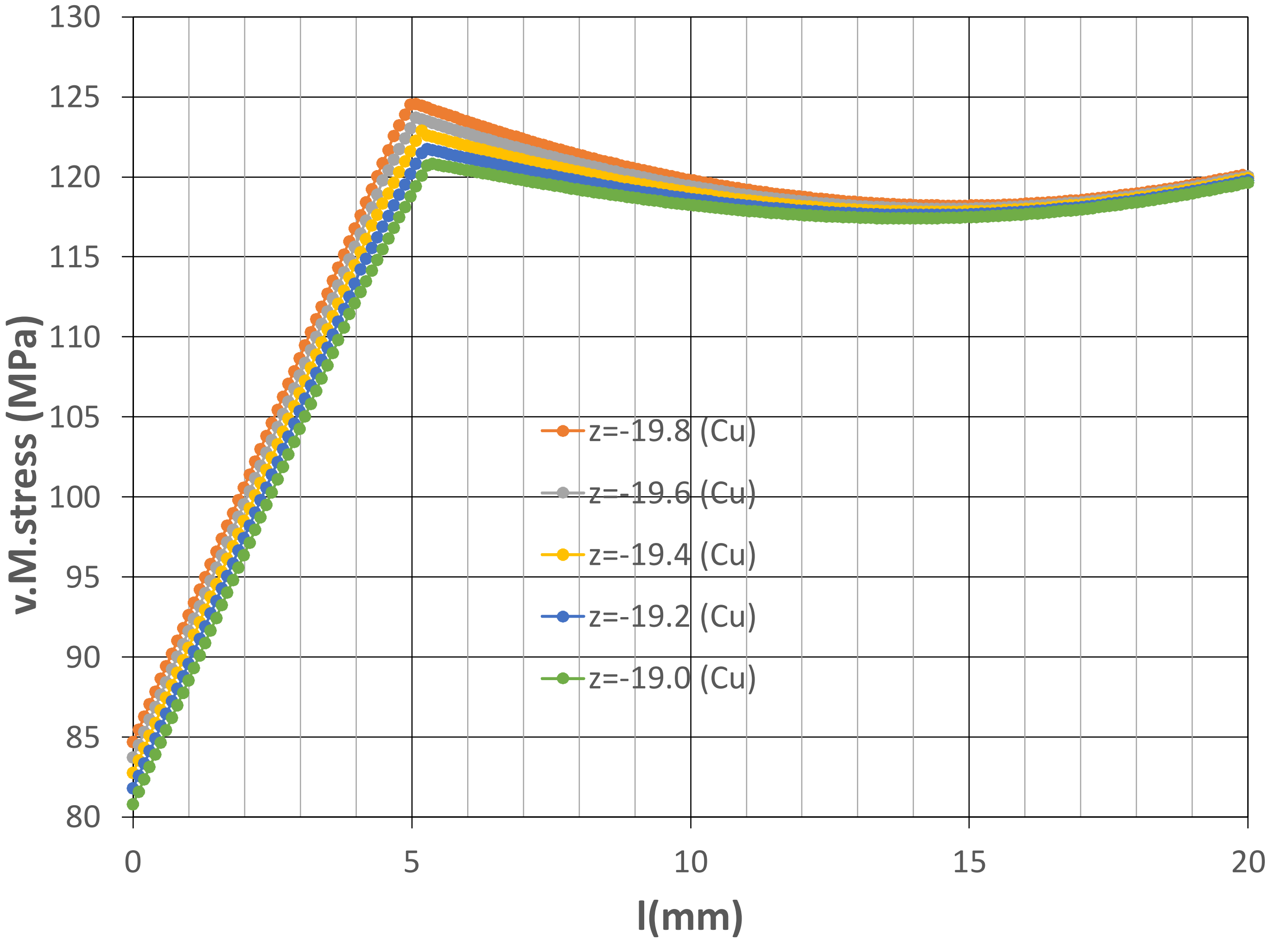
W:
(-1.0, 220, -20.2) to (-1.0, 240, -20.2)
(-1.0, 220, -20.4) to (-1.0, 240, -20.4)
(-1.0, 220, -20.6) to (-1.0, 240, -20.6)
(-1.0, 220, -20.8) to (-1.0, 240, -20.8)
(-1.0, 220, -21) to (-1.0, 240, -21)

The path at interface is 1mm far from end section.

Path at interface:

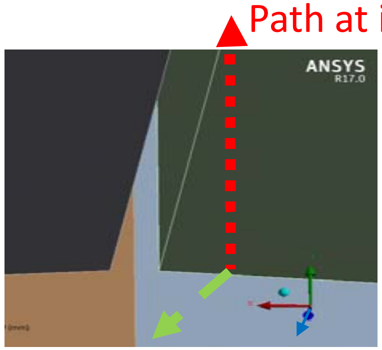


v. M. stress for Cu



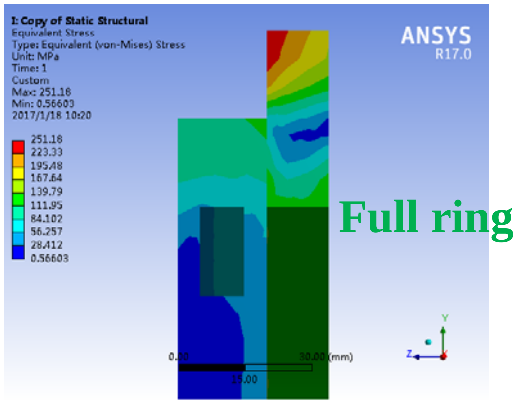
Cu
(-1.0, 220, - 19.8) to (-0.2, 240, - 19.8)
(-1.0, 220, - 19.6) to (-0.4, 240, - 19.6)
(-1.0, 220, - 19.4) to (-0.6, 240, - 19.4)
(-1.0, 220, - 19.2) to (-0.8, 240, - 19.2)
(-1.0, 220, - 18) to (-1.0, 240, - 18)

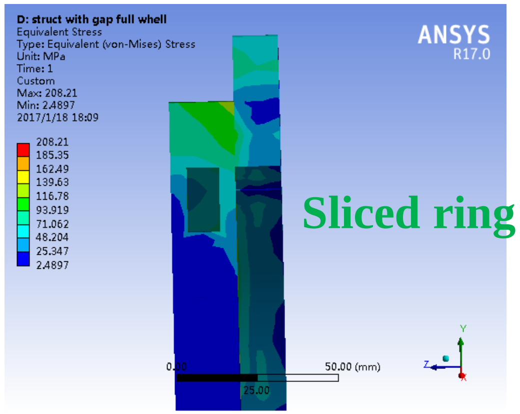
Path at interface:



Comparison and Conclusion

		Peak tempature(℃)	Peak v.M stress (MPa)	Stresses at interface (Mpa)			
				v.M.stress	sigma r	sigma phi	sigma z
Full ring	interface for W	377 at W	251 at W	40 to 130	20 to 120	-50 to 150	-15 to 10
	interface for Cu			65 to 125	-30 to 10	-140 to -50	-12 to 0
Sliced ring	interface near center of section for W	380 at W	208 at interface	40 to 100	20 to 80	40 to 100	-3 to 7
	interface near center of section for Cu			80 to 135	-10 to 25	-130 to -50	-2 to 13
	interface near end surface of section for W			20 to 150	-90 to 10	-30 to 15	-45 to -4
	interface near end surface of section for Cu			90 to 130	-90 to -30	-140 to -100	-5 to 1





- Sliced ring suffer much less stress.
- However, we need to pay attention to the interface. This can lead to fatigue and thus to loss of thermal contact.

Thanks !