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RamSeries - Validation Case 36

Thermal Stresses in a Long Cylinder

Version
15.1.0

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1 Validation Case 36 - Thermal Stress Long Cylinder

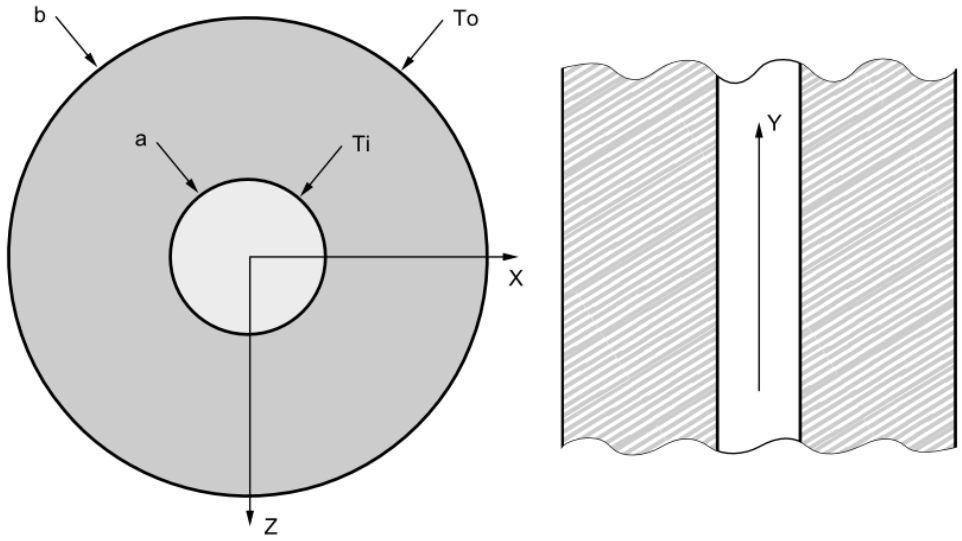
Model description

The purpose of this test is to validate the accuracy of a thermal analysis combined with a stress analysis. The following test can be performed in two different ways. The first one, is to run two separately analysis (thermal and structural analyses) and the comunication among them is carried out throught file. The second one, is to run both analyses simultaneously. Both ways are used and their results are shown in this document.

A long thick-walled cylinder is maintained at a temperature T_i on the inner surface and T_o on the outer surface. The thermal analysis allows to know the temperature distribution through the wall thickness, and the stress analysis allows to determine the tangential stress at the inner and outer surfaces.

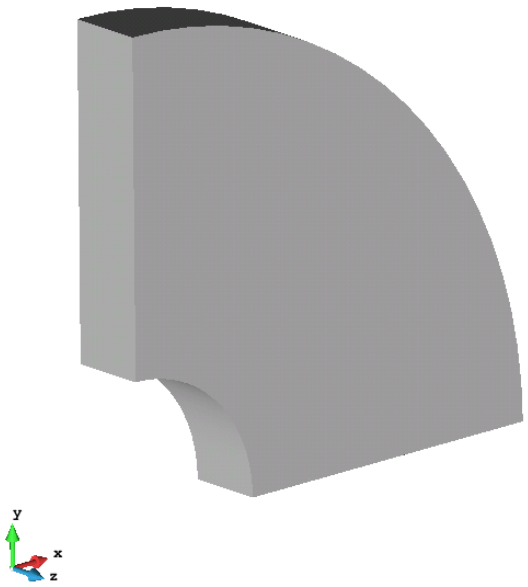
Geometric model

Following, a schematic picture is shown with dimensions.



Inner radious (a) = 4.76 mm Outer radious (b) = 15.88 mm

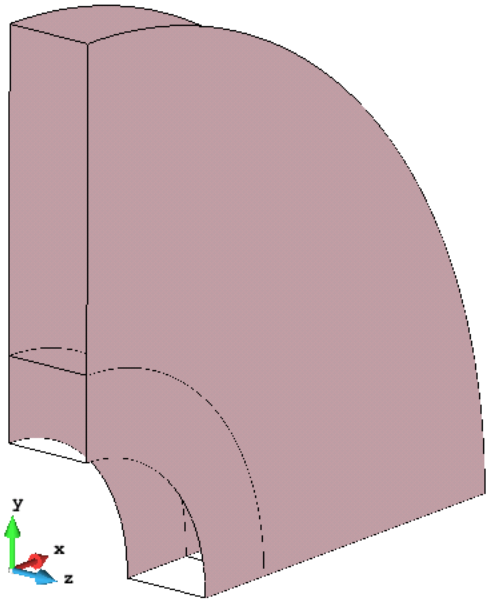
Because of the symmetry in loading conditions and in the geometry, this problem is solved as an axisymmetric problem. Moreover, the axial length is arbitrary and it is taken a value of 2.54 mm because model is a long cylinder.



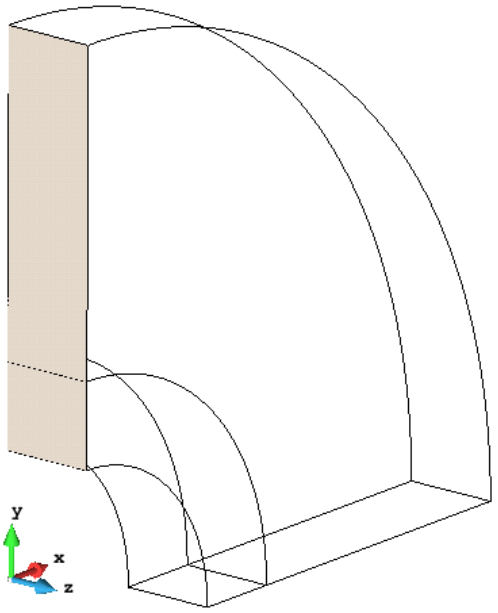
Geometric model used to perform analysis with TDYN

Restrictions

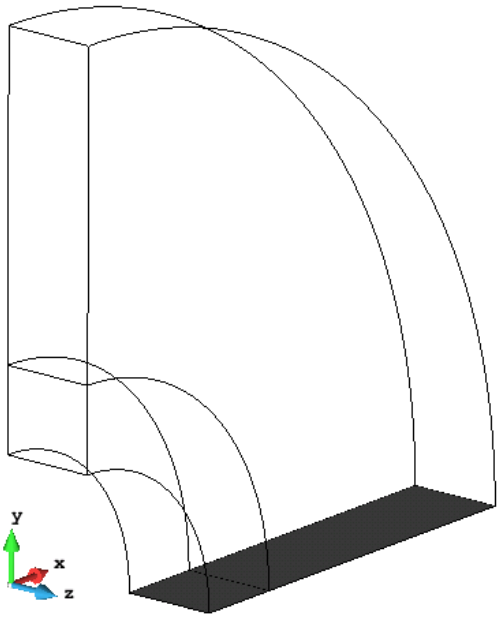
To create symmetry conditions, the following restrictions are applied:



Restriction: Z direction



Restriction: X direction



Restriction: Y direction

Temperature conditions

T_o = -17.78 ºC (Outer surface temperature)

T_i = -18.33 ºC (Inner surface temperature)

Material properties

E = 206843 MPa (Young's modulus)

v = 0.3 (Poisson's ratio)

α = 2.583e-5 1/ºC (thermal expansion coefficient)

k = 62.3 W/mK (thermal conductivity)

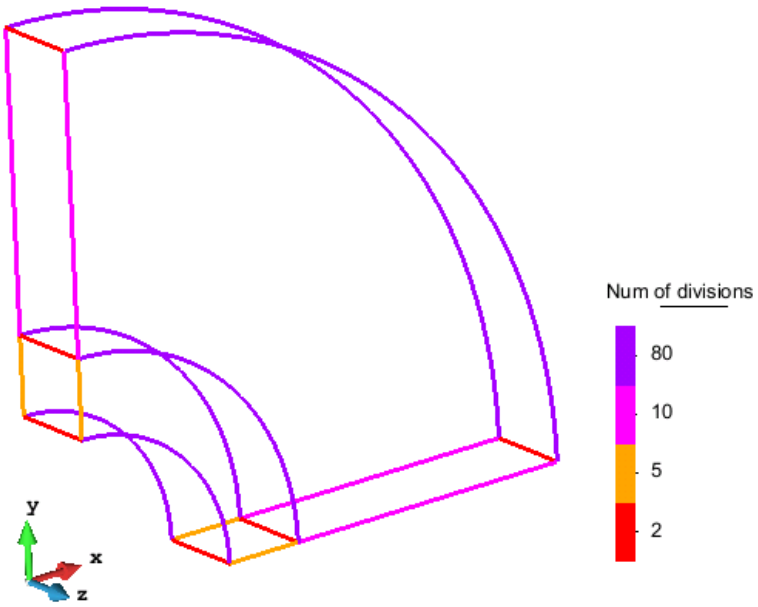
Results

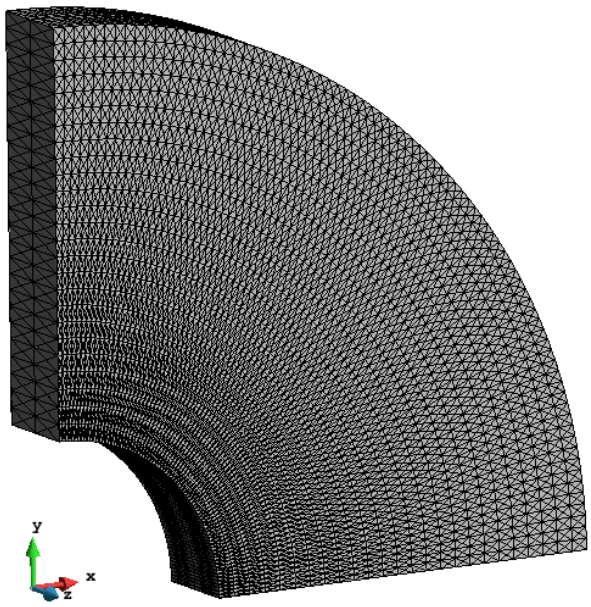
A thermomechanic problem must be solved in two steps:

- A thermal analysis allows to know the temperature distribution for each step.
- A mechanic analysis that calculates the displacement and stress for each step using the results obtained in the previous thermal analysis.

Mesh

A structural mesh of tetrahedra is used. The following image shows the number of divisions applied in each edge.

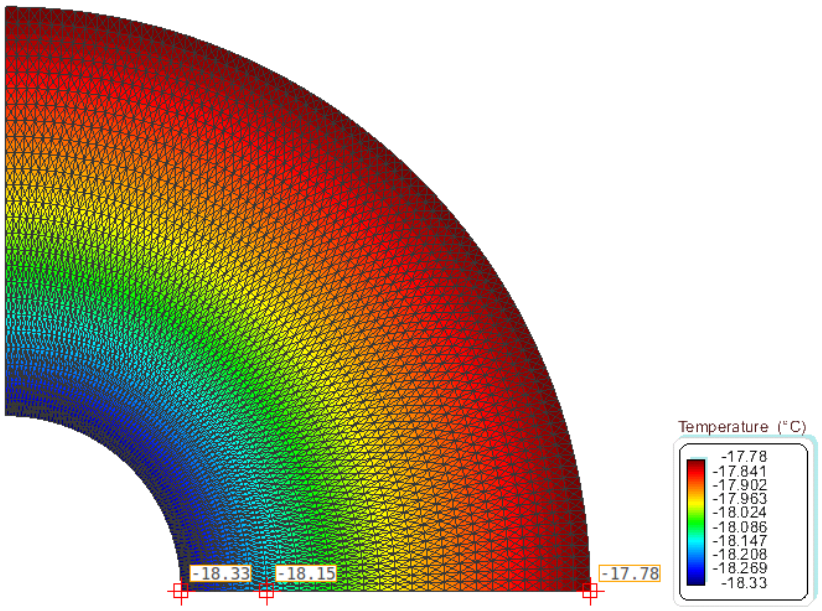




Mesh of tetrahedra. This mesh contains 114320 elements and 24528 nodes.

Thermal analysis

Below, the temperature distribution calculated in a thermal analysis performed with TDYN is shown.



Temperature distribution

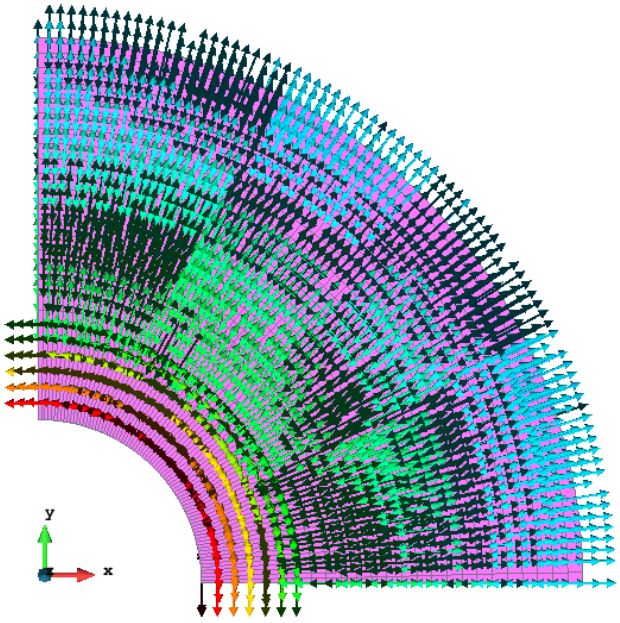
And then, the results obtained in thermal analysis are compared with the results shown in Reference[1].

	Target (Ref.[1]) [ºC]	TDYN Results [ºC]	Error [%]
Temperature (X=4.76 mm)	-18.33	-18.33	0
Temperature (X=7.08 mm)	-18.15	-18.15	0
Temperature (X=15.88 mm)	-17.78	-17.78	0

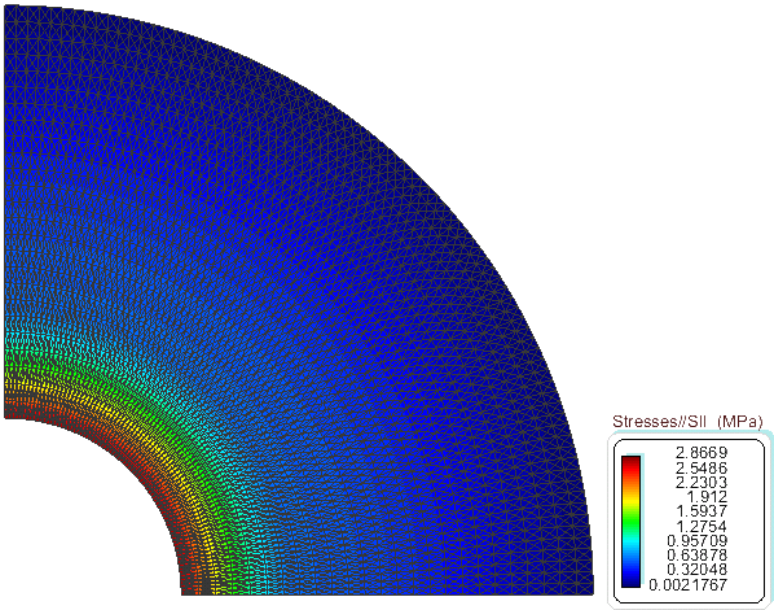
Stress analysis

Below, the tangential stress calculated in a structural analysis performed with RamSeries is shown.

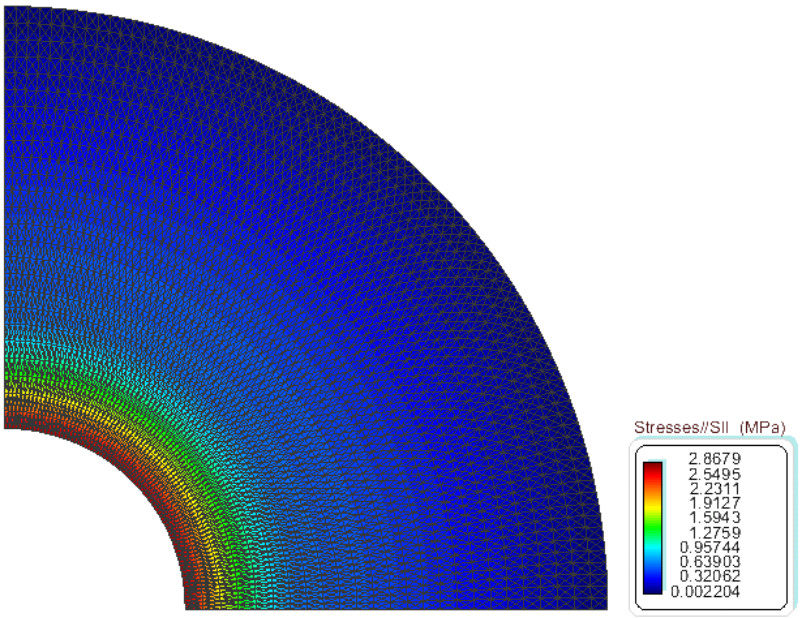
Tangential stress at the inner surface corresponds to second principal stress:



Second principal stress directions (Sii). On the inner surface, second principal stress corresponds to tangential stress.

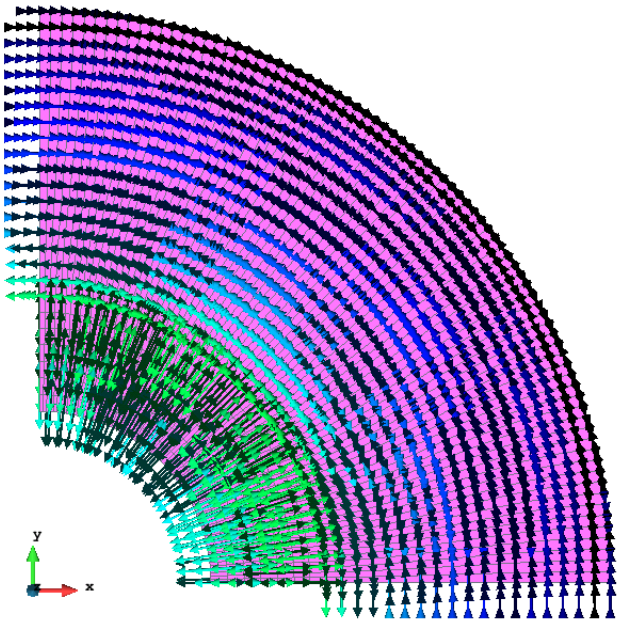


Results of separated analyses. Tangential stress on the inner surface.

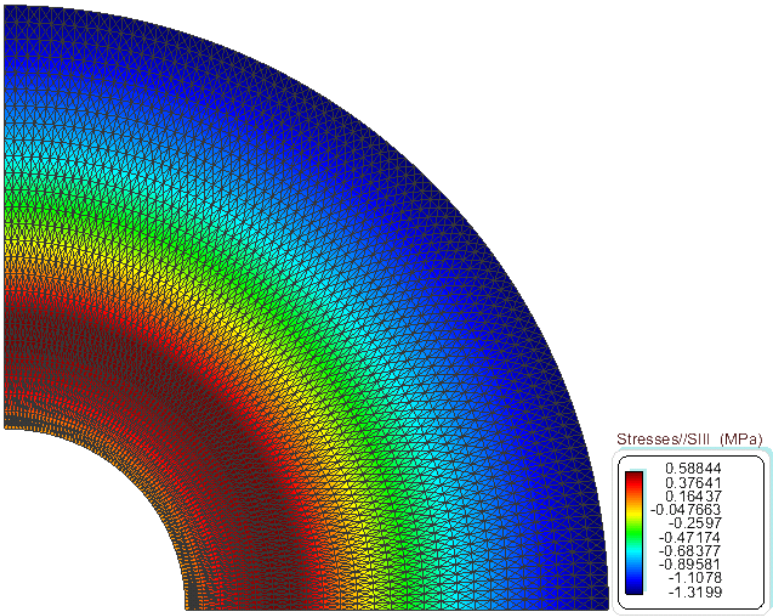


Results of coupled analyses. Tangential stress on the inner surface.

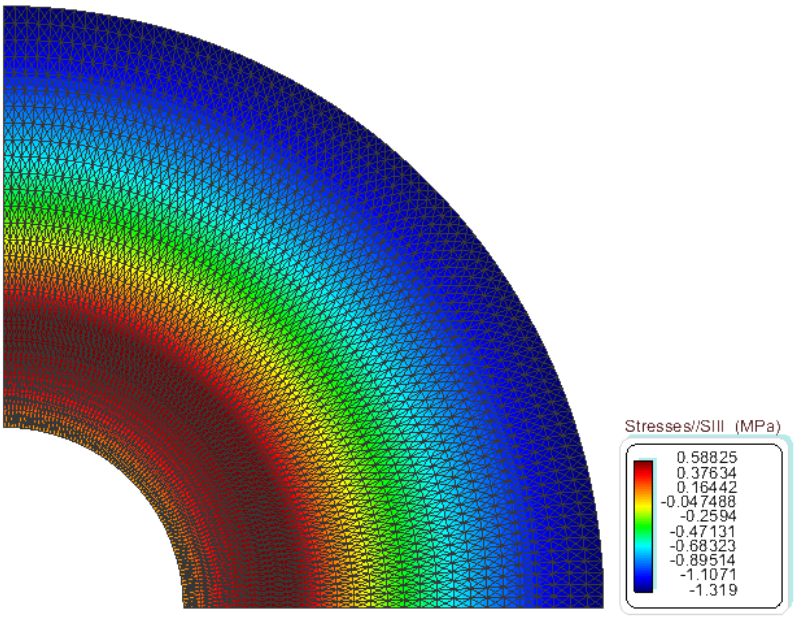
And tangential stress on the outer surface corresponds to third principal stress:



Third principal stress directions (Siii). At the outer surface, third principal stress corresponds to tangential stress.



Results of separated analyses. Tangential stress on the outer surface.



Results of coupled analyses. Tangential stress on the outer surface.

Sumarize of results

Below, a table with the numerical results obtained by separated analyses and other table with numerical results from coupled analysis are shown. Both tables compare numerical results with the values form Reference 1.

- Separated analyses:

	Target (Ref.[1]) [MPa]	RamSeries Results [MPa]	Error [%]
Tangential Stress inner surface	2,9	2,8	3
Tangential Stress outer surface	-1,3	-1,3	0

- Coupled analysis:

	Target (Ref.[1]) [MPa]	RamSeries Results [MPa]	Error [%]
Tangential Stress inner surface	2,9	2,9	0
Tangential Stress outer surface	-1,3	-1,3	0

References

[1] ANSYS. Verification Manual for Workbench, pag 161-162. April 2009. Release 12.0.

Validation Summary

CompassFEM version	15.1.0
Tdyn solver version	15.1.0
RamSeries solver version	15.1.0
Benchmark status	Successfull
Last validation date	27/11/2018