PO1C13

Design of the spacer for the multi-layer pressure vessel installed in the reactor pool

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2021. 10. 21.

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01 Introduction

Introduction

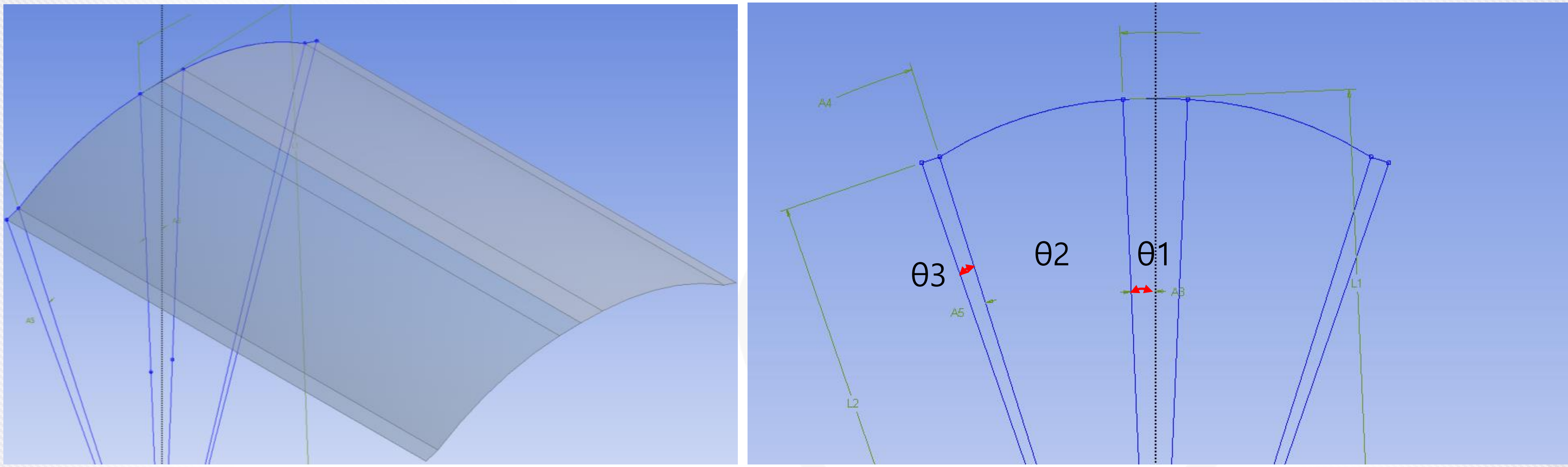
Objective

- In the case of the multi-layer pressure boundary assembly, the cooling of the inner layers should be considered also to avoid overheating the layer due to nuclear heating.
- Thus, the conduction through the spacer between the layers would be one of the possible approaches for sufficient cooling of the vacuum chamber as the inner layer.
- In this case, the trade-off between stress and temperature should be considered in the design stage because the stiffer spacer, the lower the thermal resistance.
- In this study, stiffness and the thermal resistance of the spacer between the two cylinder is investigated and reviewed whether the spacer can be contributed to the thermal conduction meaningfully.

02
Methods and Results

Methods and Results

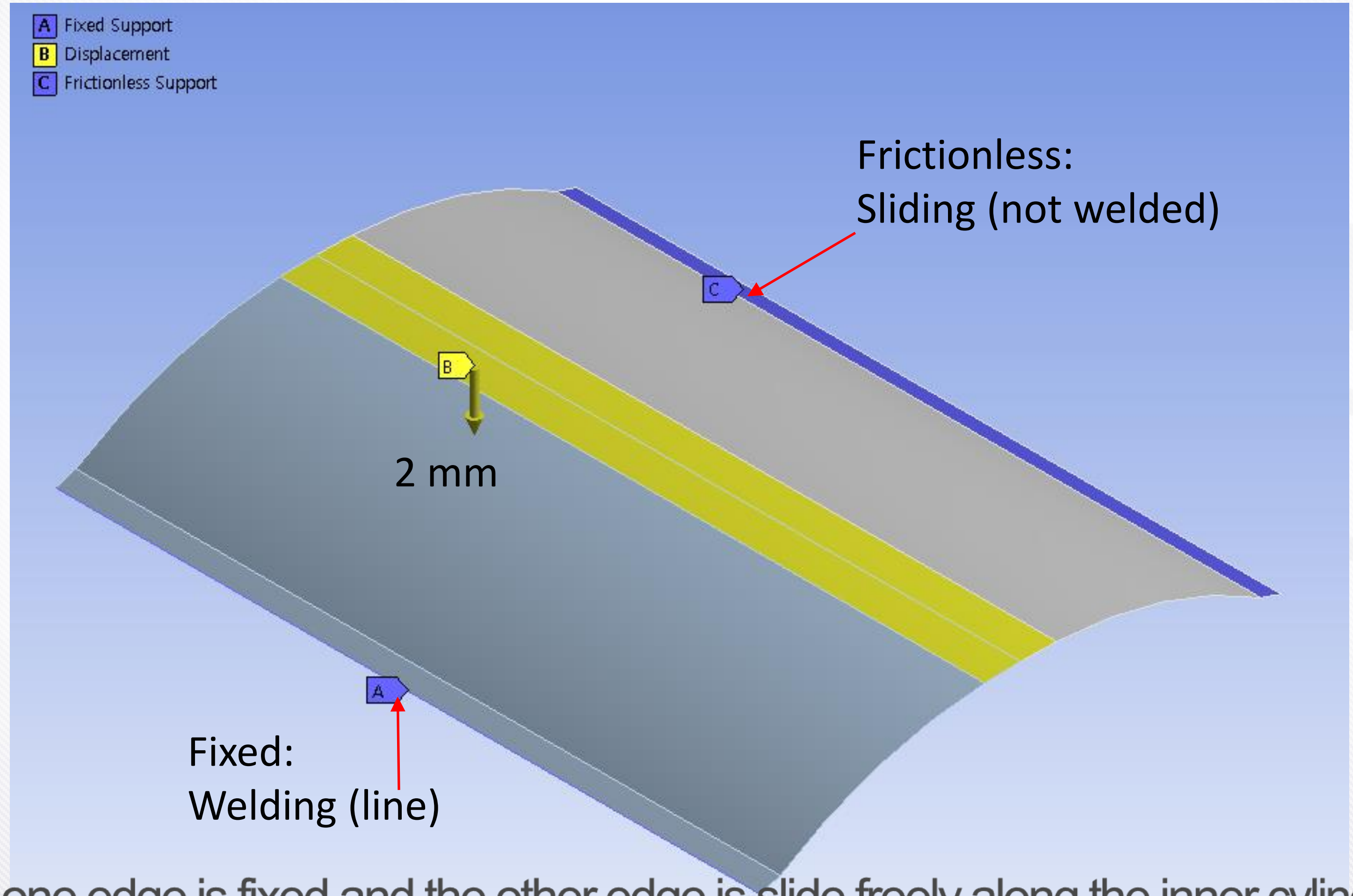
Design parameter



Parameters	Description	Objective
t	Thickness: 0.41 mm and 0.508 mm.	Trade off between stiffness and thermal resistance
θ1	Half-angle for the contact region with outer cylinder	Sensitivity of the contact surface area
θ2	Angle for the transient region inner and outer cylinder	Trade off between stiffness and thermal resistance
θ3	Angle for the contact region with inner cylinder	Sensitivity of the contact surface area

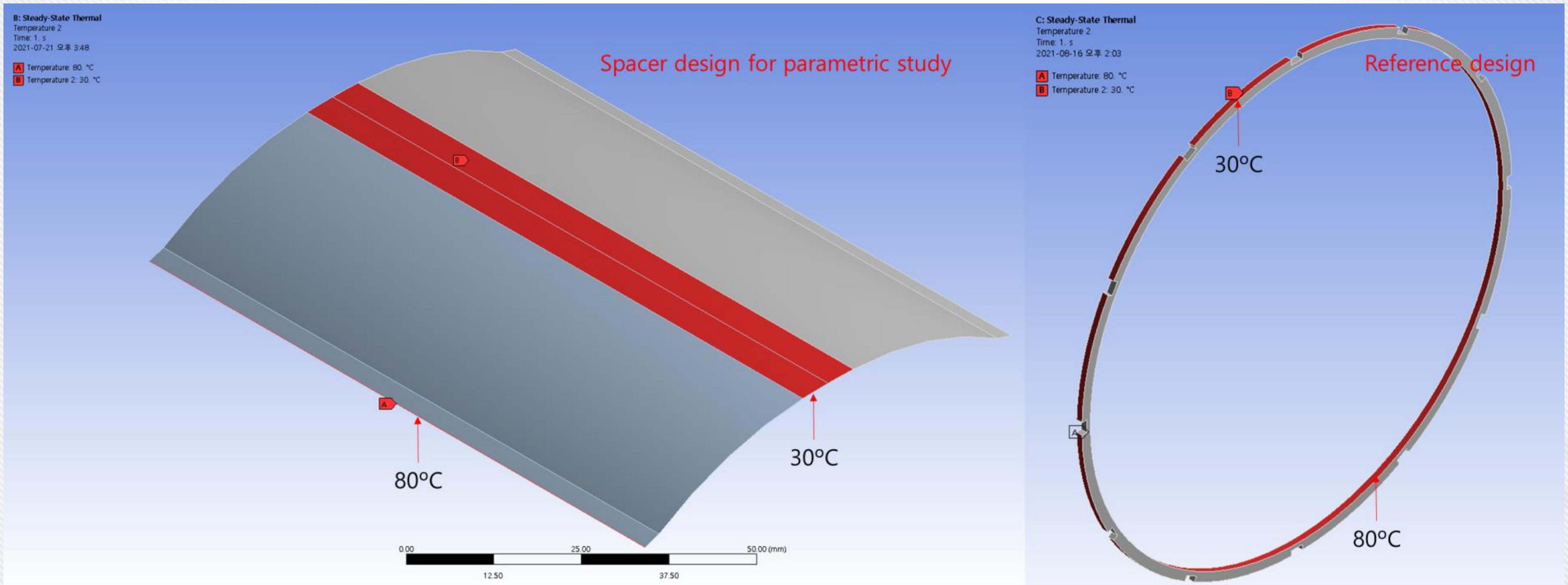
Methods and Results

Boundary condition for the structural analysis



- Only one edge is fixed and the other edge is slide freely along the inner cylinder surface to prevent excessive stress.

» Boundary condition for the thermal analysis



- The temperature of the fixed edge is 80ºC, and the temperature of the contact surface with the outer cylinder surface is 30ºC.
- The temperature of the inner surface of reference spacer is 80ºC, and the temperature outer surface is 30ºC.
- The heat transfer rate through reference spacer, is used as a reference value.

Reverse engineering procedure

θ1(°)	θ2(°)	θ3(°)	t	$\sigma_m+\sigma_b$ (MPa)	W
2.5	15	1.5	0.500	335.0	11.52
2.5	7	1.5	0.500	1329.3	21.71
2.5	15	1.5	0.410	277.7	9.45
2.5	7	1.5	0.410	1111.4	-17.77
2.5	20	1.5	0.410	162.4	-7.28
2.5	25	1.5	0.410	110.9	-5.92
1.5	25	1	0.410	114.3	-6.03
2.5	15	1.5	0.508	227.8	11.71
2.5	20	1.5	0.508	132.7	9.02
2.5	25	1.5	0.508	90.8	7.33
2.5	22.5	1.5	0.508	108.6	8.09
1.5	22.5	1	0.508	112.5	8.26

Final design

- The temperature of the fixed edge is 80ºC, and the temperature of the contact surface with the the results clearly show that θ2 is the major factors for the trade-off between stiffness and thermal resistance, and heat transfer rate is not sensitive to the change of the contact surface area (θ1 and θ3).
- The heat transfer rate of the spacer is about 10 W if it satisfies the structural requirement. which is much smaller than that of the reference spacer design, 3419 W.

03
Conclusions

Conclusions

- The parametric study shows the spacer can absorb uncertainty due to the misalignment or welding contraction without excessive stress and the contact surface area is not a critical factor for the heat transfer.
- However, additional heat transfer mechanism, such as aluminum mesh, could be introduced additionally, because heat transfer rate through the spacer is too small comparing with the reference spacer.

04
Acknowledgement & References

Acknowledgements & References

Acknowledgements

• This work was supported by the Ministry of Science and ICT (MSIT) grant funded by the Korean government.

References

[1] ASME Bolier and Pressure Vessel Code, Section II Part D, Material, American Society of Mechanical Engineers, 2013

THANK YOU