Al/CFRP interface cohesive zone fracture modeling in type-III composite vessel during cooling : Experiment based inverse simulation optimization

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Introduction:

Type-III composite overwrapped pressure vessels (COPVs) composed of inner Al liner and fiber reinforced materials i.e. CFRP/GFRP widely used in fuel cell vehicles because of their high strength-to-weight ratios [1].
However, debonding defects at CFRP and Aluminum liner interface may arise during COPV`s manufacturing and operation stages [2].
This defect endanger the structural integrity, even become threat to human safety. So, comprehensive Al-CFRP interfacial fracture study with initial debonding is necessary to give better design guidance of COPV.

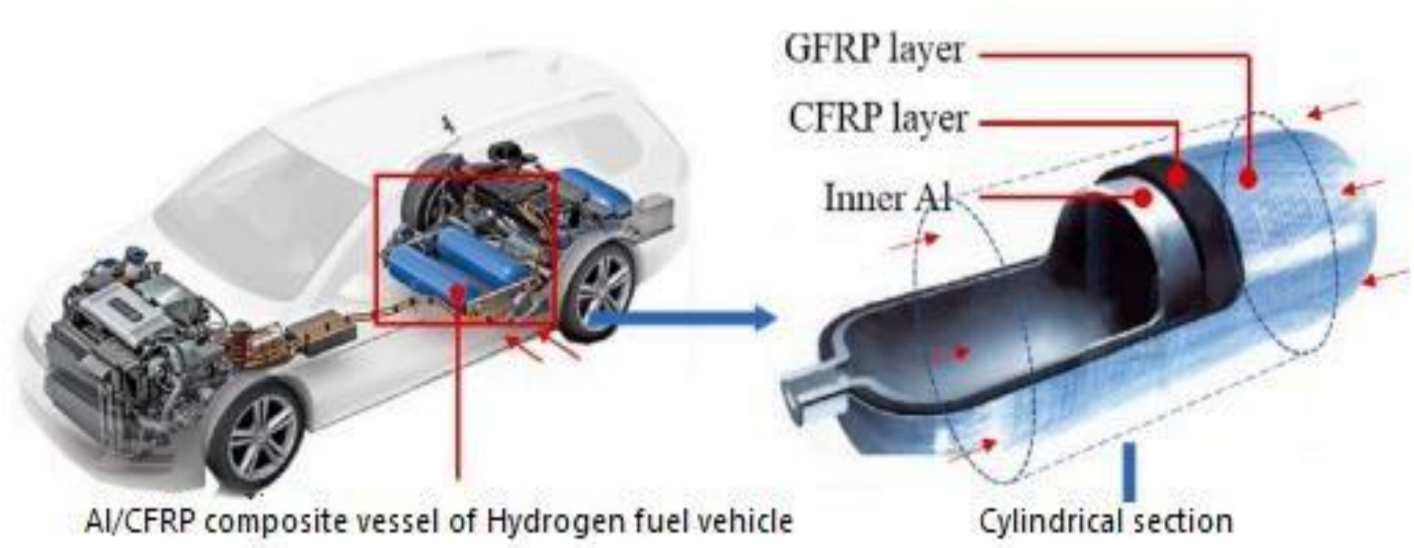


Fig 01: A typical hybrid structure of Al/CFRP/GFRPvessel . Reproduced from ref. [3]

Research objectives:

Cohesive zone modeling of Al-CFRP interfacial crack growth of COPV based on experiment based inverse simulation
Cryogenic cooling and initial crack effects study on COPV burst strength

Materials and methods:

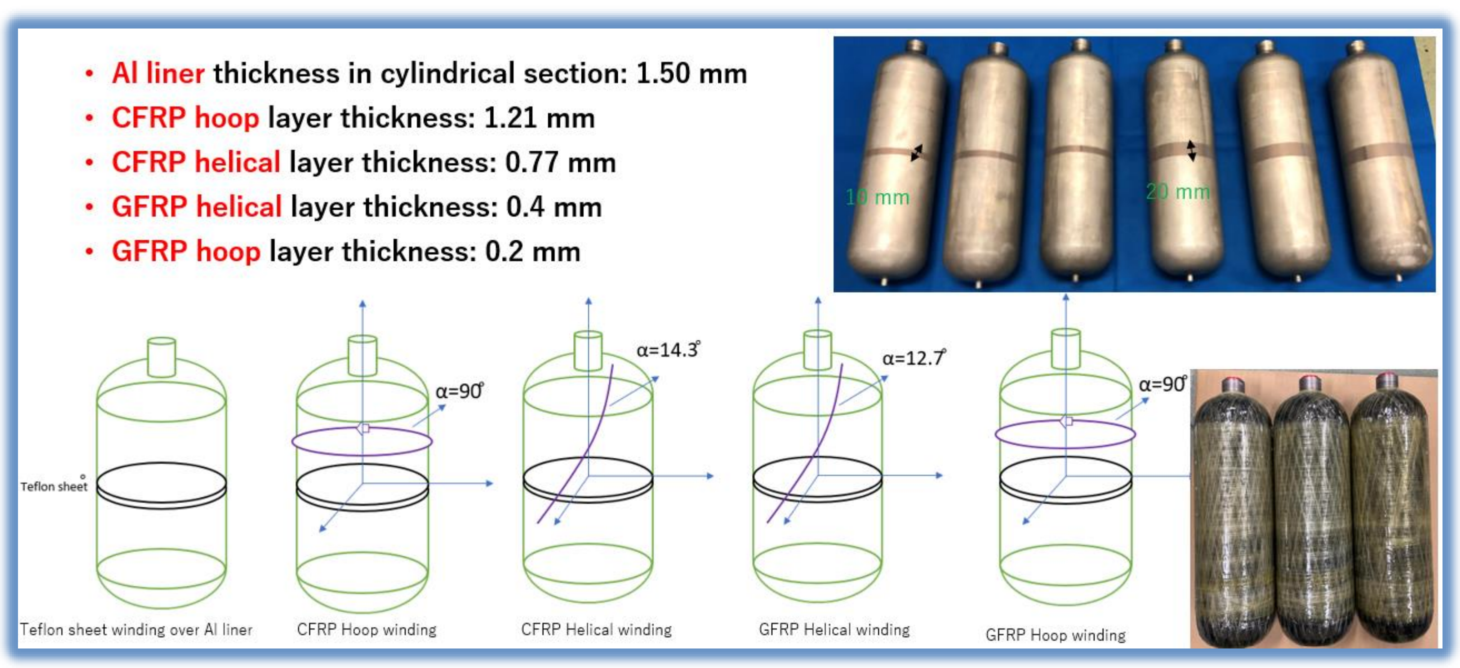


Fig 02: COPV manufacturing illustration and experiment samples

Experiment set up:

i. 03 COPV samples with no initial crack, 10mm and 20mm used in N2 gas cooling tests as shown in following typical diagrams

ii. Samples abbreviated as: COPV-0, COPV-10 and COPV-20

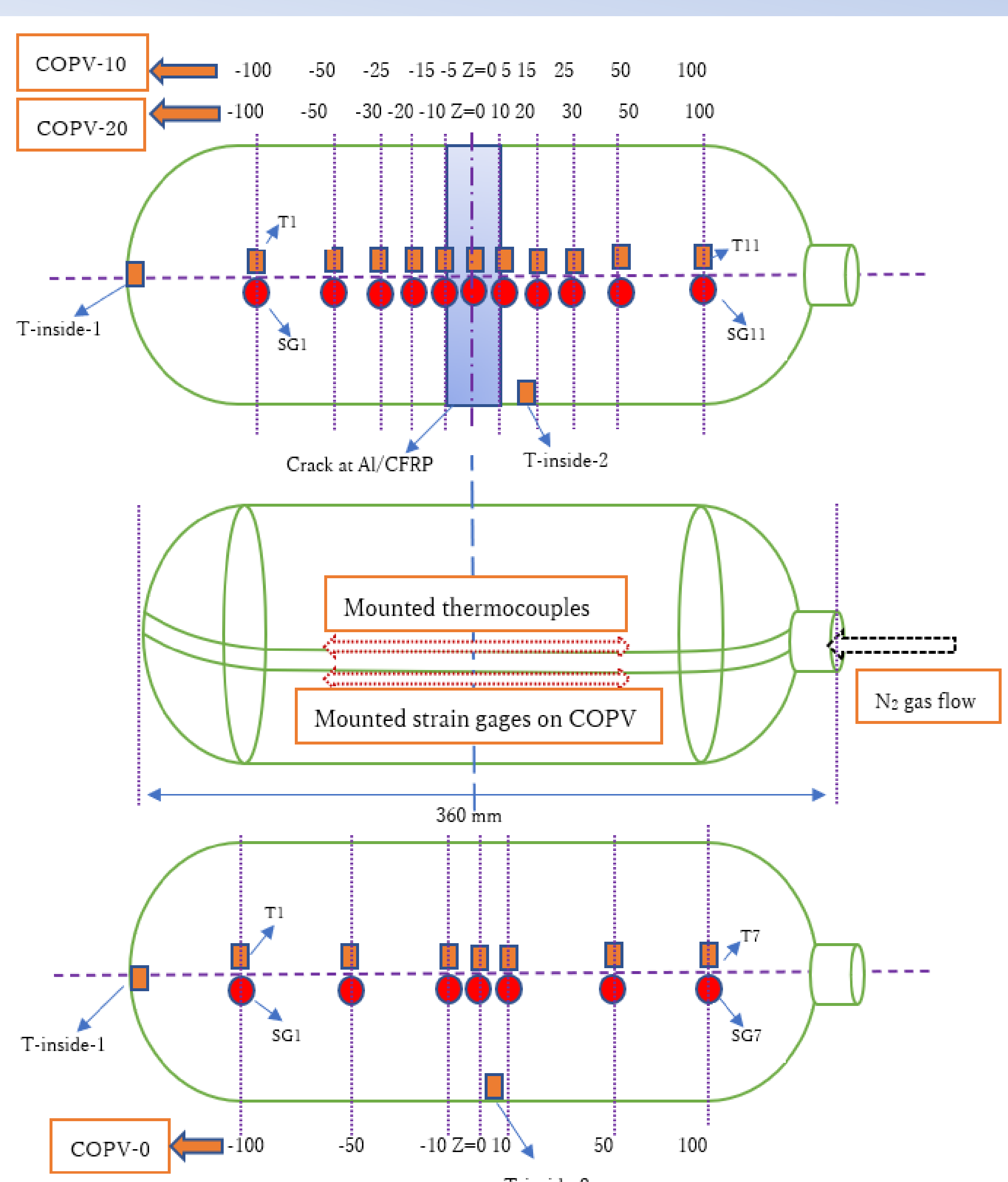
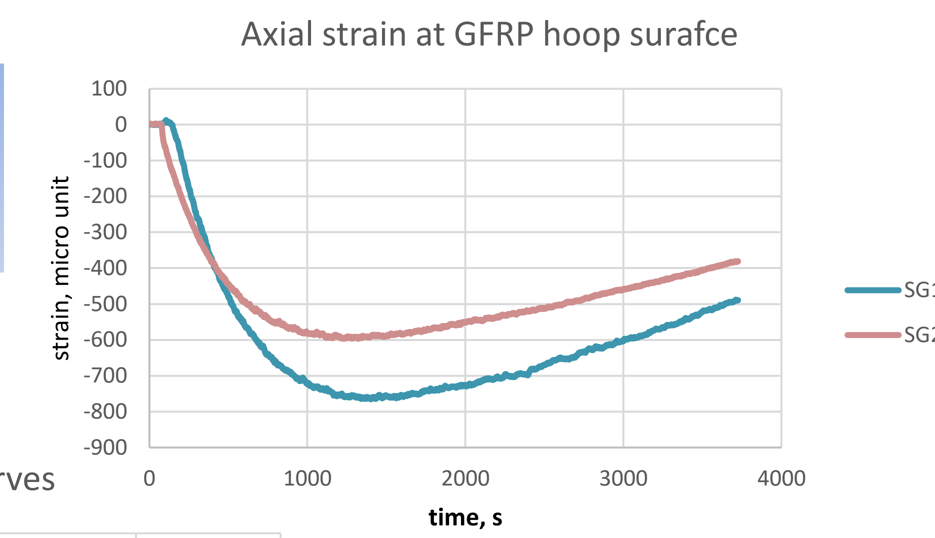
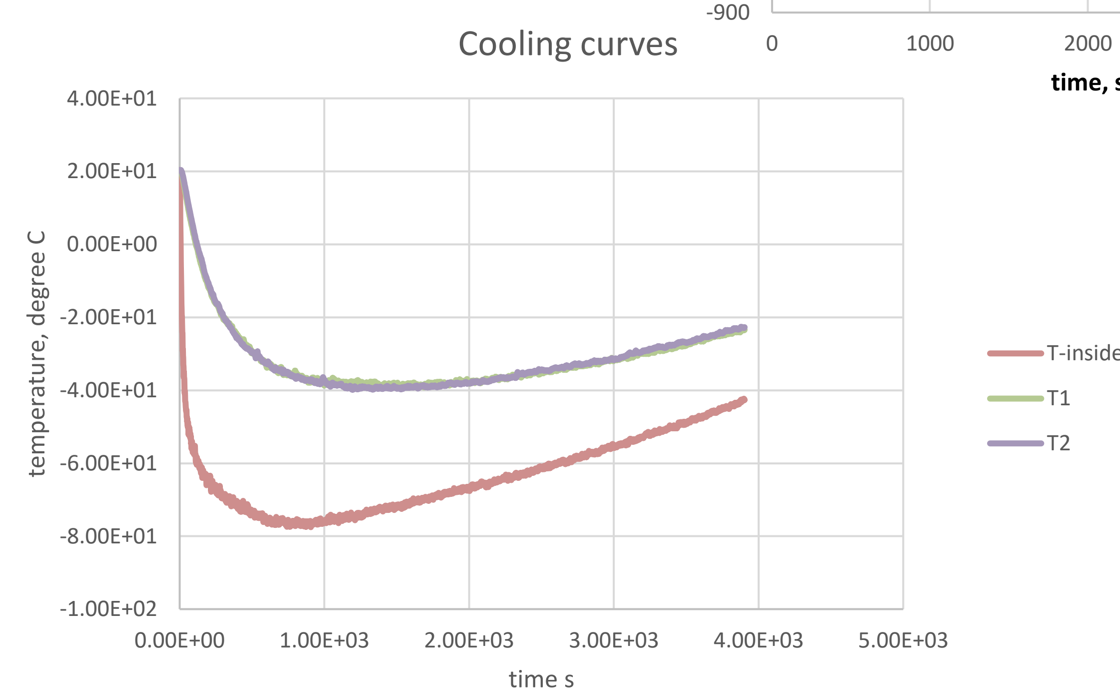


Fig 03: Typical experiment set up

Experiment case study:

A case study of GFRP hoop surface two locations axial strain and temperature change measurements [4]





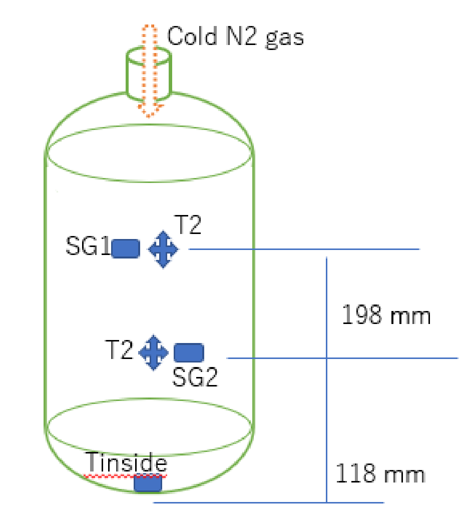


Fig 04: axial strain and temperature measurement in COPV sample

Simulation basic and case study:

To approach the Al/CFRP90 interface crack growth surface based cohesive zone modeling technique (CZM) used in FEM analysis
Cohesive contact restricted to a subset of slave nodes in Al/CFRP90 interface

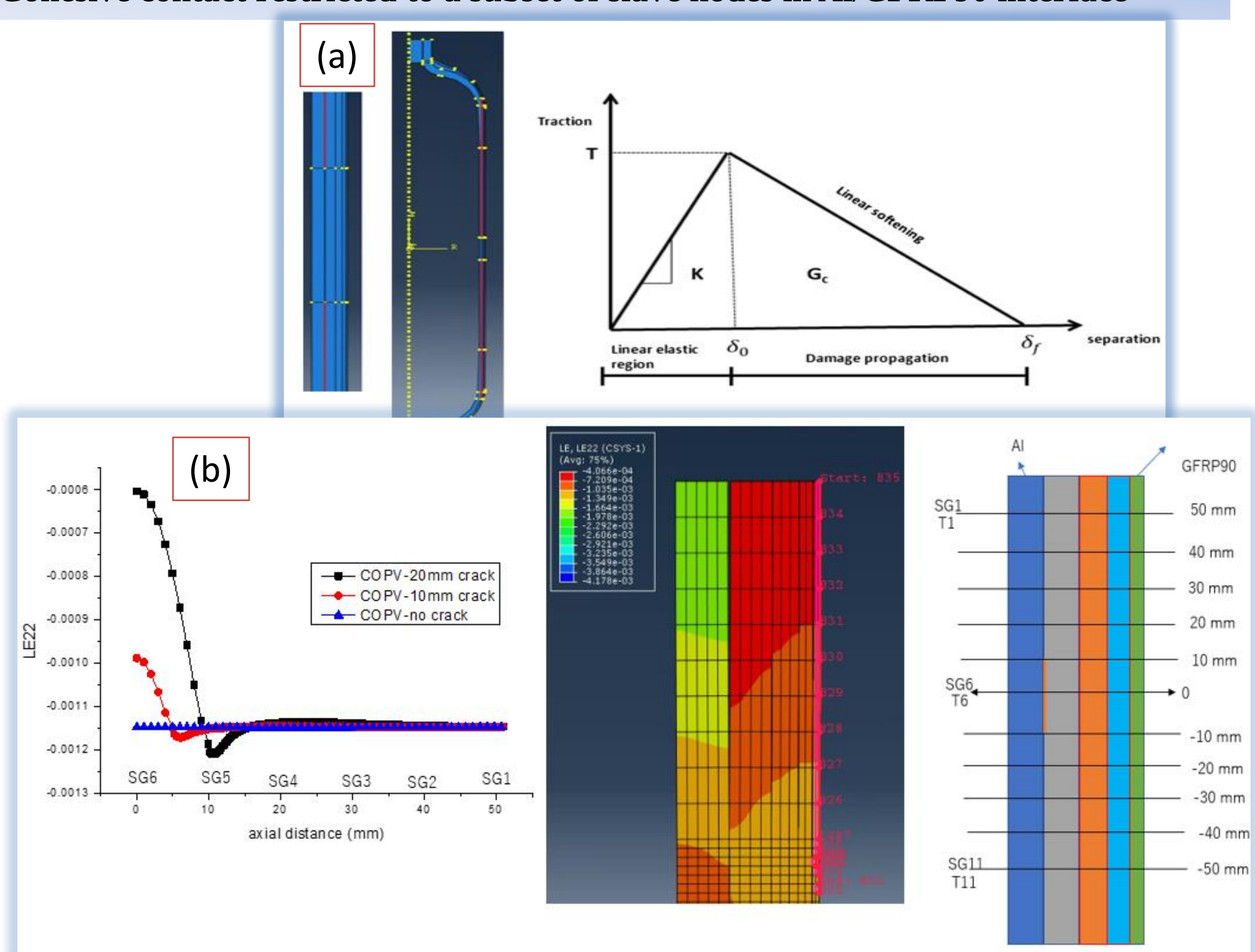


Fig 05: (a) simulation model and interface fracture criteria(b) simulation case study

Conclusion:

Research gap and objectives identified
Experimental plan outlined
Experiment case study performed
Simulation case study performed
Finally experiments with target 03 samples will be performed
Experiment based simulation optimization results will be discussed

References:

1. Harada, S., Arai, Y., Araki, W., Iijima, T., Kurosawa, A., Ohbuchi, T., & Sasaki,N. (2018) Composite Structures, 190, 79-90.
Zhao, J., Yang, L., Wang, H., Zhao, J., Li, N., Chang, L., ... & Qiu, J. (2022).
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3. Cui, Z., Liu, Q., Sun, Y., & Li, Q. (2020). Composites Part B: Engineering, 200,108341.
4. Kang, Z., Yanzhong, L., Yuan, M., Lei, W., Fushou, X., & Jiaojiao, W. (2018). Experimental study on cool down characteristics and thermal stress of cryogenic tank during LN2 filling process. Applied Thermal Engineering, 130, 951-961.