N. YOSHIKAWA LAB.

[Developments of Multi-scale Solid Mechanics]

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Multi-scale Solid Mechanics

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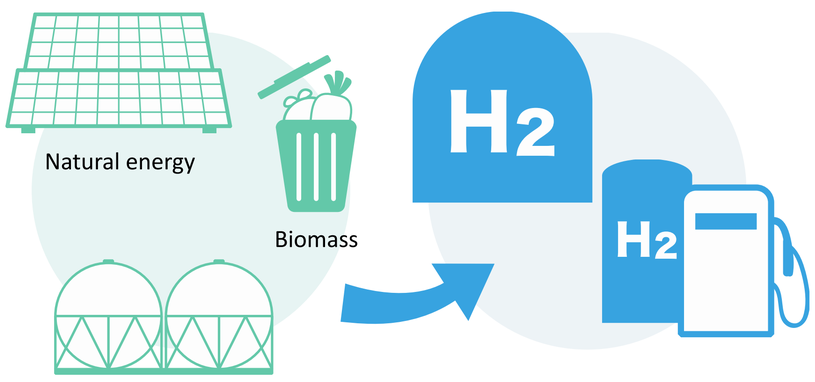
High pressure hydrogen container to promote hydrogen society

In order to promote a hydrogen society, it is important to develop a large capacity high pressure hydrogen container that supports high pressure hydrogen management. From the viewpoint of light weight and long life reliability, we have developped containers made of Carbon Fiber Reinforced Plastics (CFRP). To ensure reliability, we research on limit strength design based on multiscale simulation.

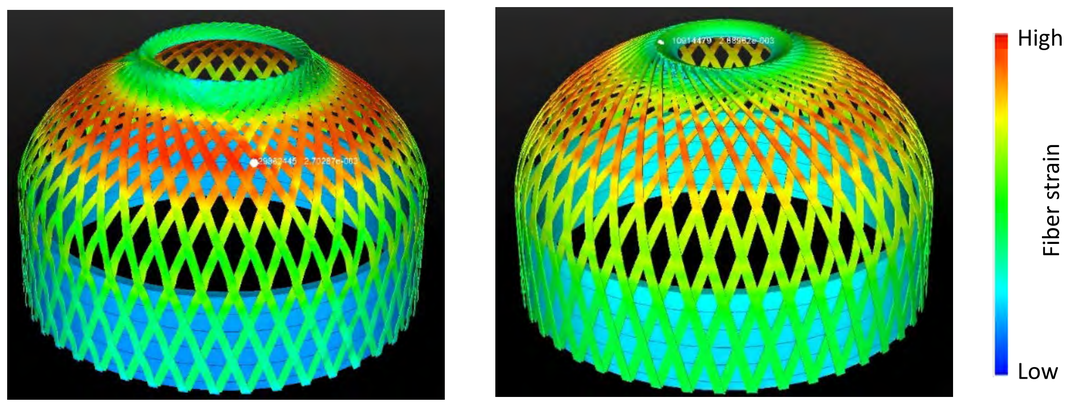


Fossil fuel H_2 container and station

CFRP accumulator [1]

Multi filament winding method†

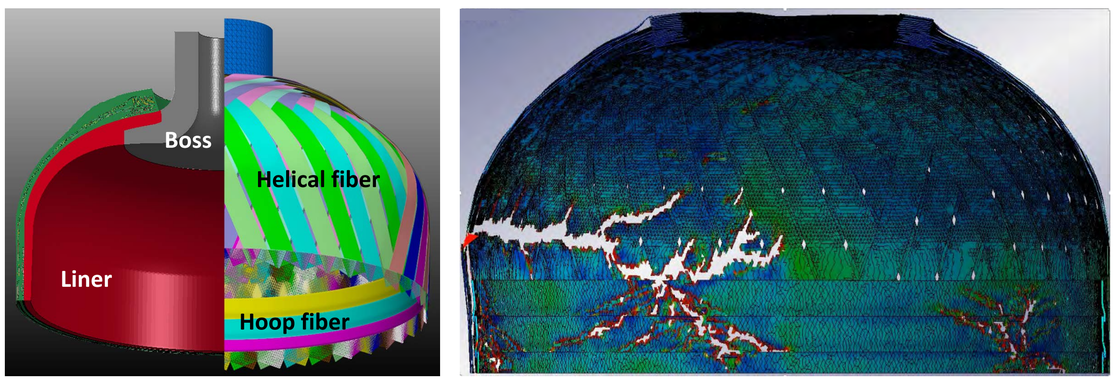
The high pressure hydrogen container made by CFRP is manufactured by a filament winding (FW) method. In the conventional single FW method, stress concentration occurs at the crimps of the fiber bundles, and causes low strength. Therefore, we have developed a multi FW method that wraps with 100 fiber bundles at the same time without crimp. We demonstrate its mechanical advantage and develop a optimimum design method by meso-scale simulation.



Fiber strain of single FW Fiber strain of multi FW

Impact damage of CFRP high pressure hydrogen container

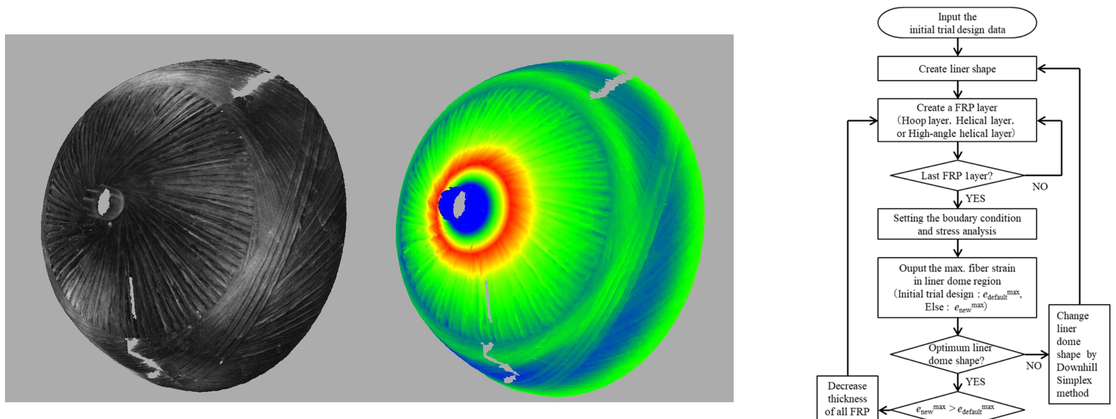
To ensure high degree of reliability of CFRP hydrogen container of 700MPa for fuel cell vehicles, the series test simulating its usage environment is mandatory in GTR13. The test takes a half year, so that rational alternatives are required. We have developed an impact damage evaluation method to eliminate the drop test based on a meso-scale simulation.



Meso-scale model of type IV container (left) and result of impact analysis (right: fiber direction strain)

Modeling and shape optimization of CFRP high pressure hydrogen container†

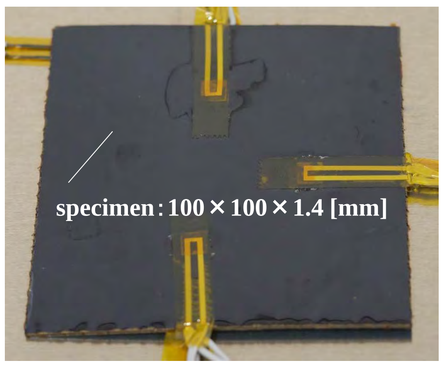
We developed a modeling software that creates mesh data generated from actual surface information of the CFRP high pressure hydrogen container. Furthermore, we derive a mathematical model of dome shape and winding path of fiber bundle, so as to construct a shape optimization algorithm.



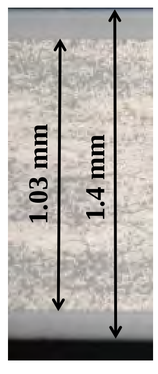
Measure of surface data by visible light (left) and optimization algorithm (right)

Manufacturing simulator for thermoplastic CFRP††

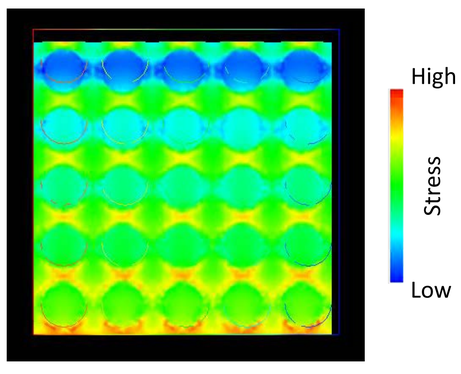
Thermoplastic CFRP is promising from the viewpoint of mass productivity. Initial defects such as residual stress and deviating fiber orientation occur due to non-uniform distribution of temperature during press molding. In order to realize high reliability in strength with prediction of the defects, we have developed a thermoplastic CFRP manufacturing simulator.



Specimen for heat press forming



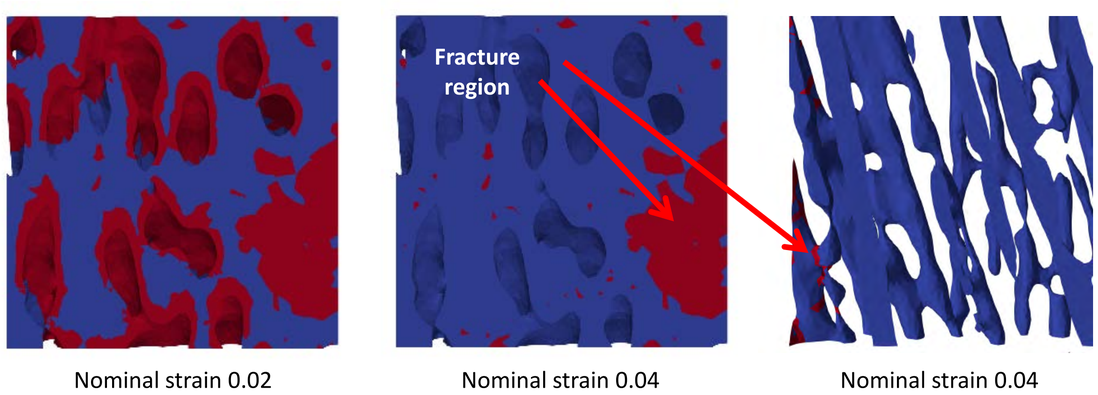
Sectional view



Normal stress on sectional surface

Strength model for short fiber thermoplastic CFRP†††

The injection and press molding of short fiber thermoplastic CFRP contributes match for production of automobile part in complicated shape. We have difficulty to predict the strength after molding, since the local volume fraction and orientation of carbon fibers are randomly distributed. We have developed a statistical strength model by means of micro-scal nonlinear fracture simulation.



Nominal strain 0.02 Nominal strain 0.04 Nominal strain 0.04

Fracture simulation of micro-scale model (left・center: resin, right: carbon fiber)

[1] SAMTECH Co. Ltd., http://www.samtech.co.jp, 2018/4/28 inspected. † This work is based on results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO) and joint research with TEIJIN LIMITED. and MURATA MACHINARY, Ltd.
†† This research is supported by MEXT as “Priority Issue on post-K computer” Priority Issue 8 (Development of innovative design and production processes that lead the way for the manufacturing industry in the near future). ††† This work is supported by Innovative Structural Materials Association.