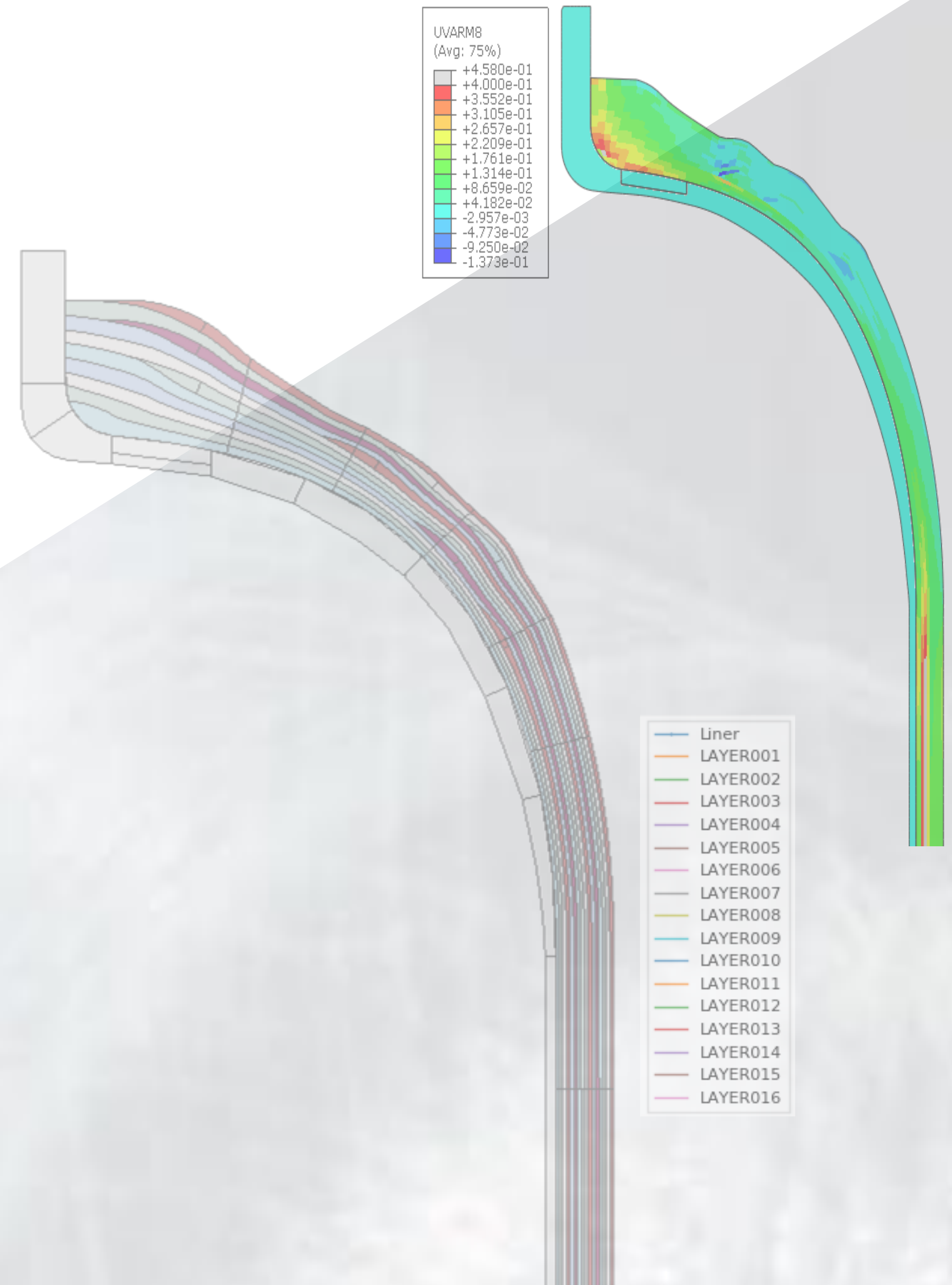
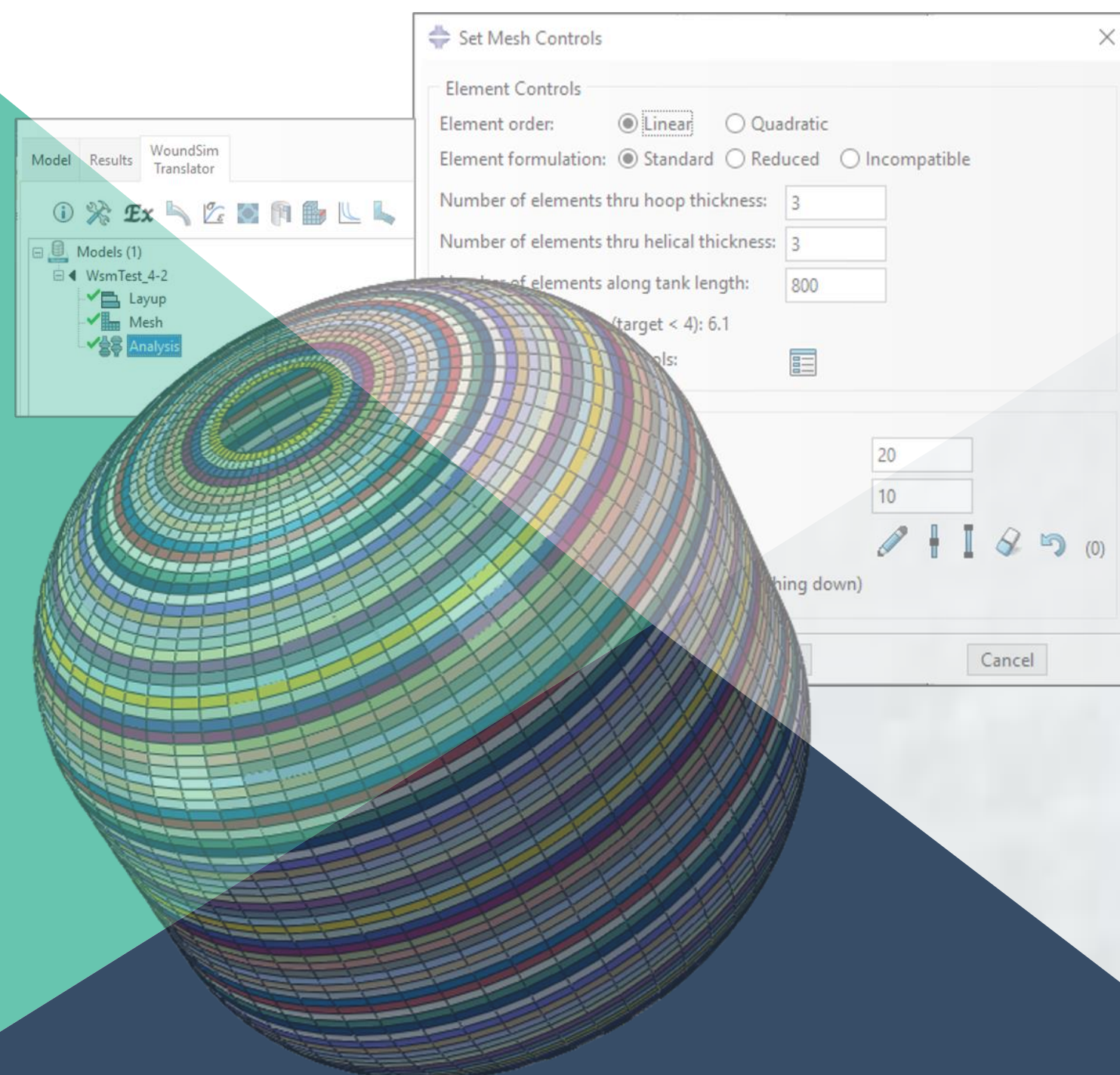


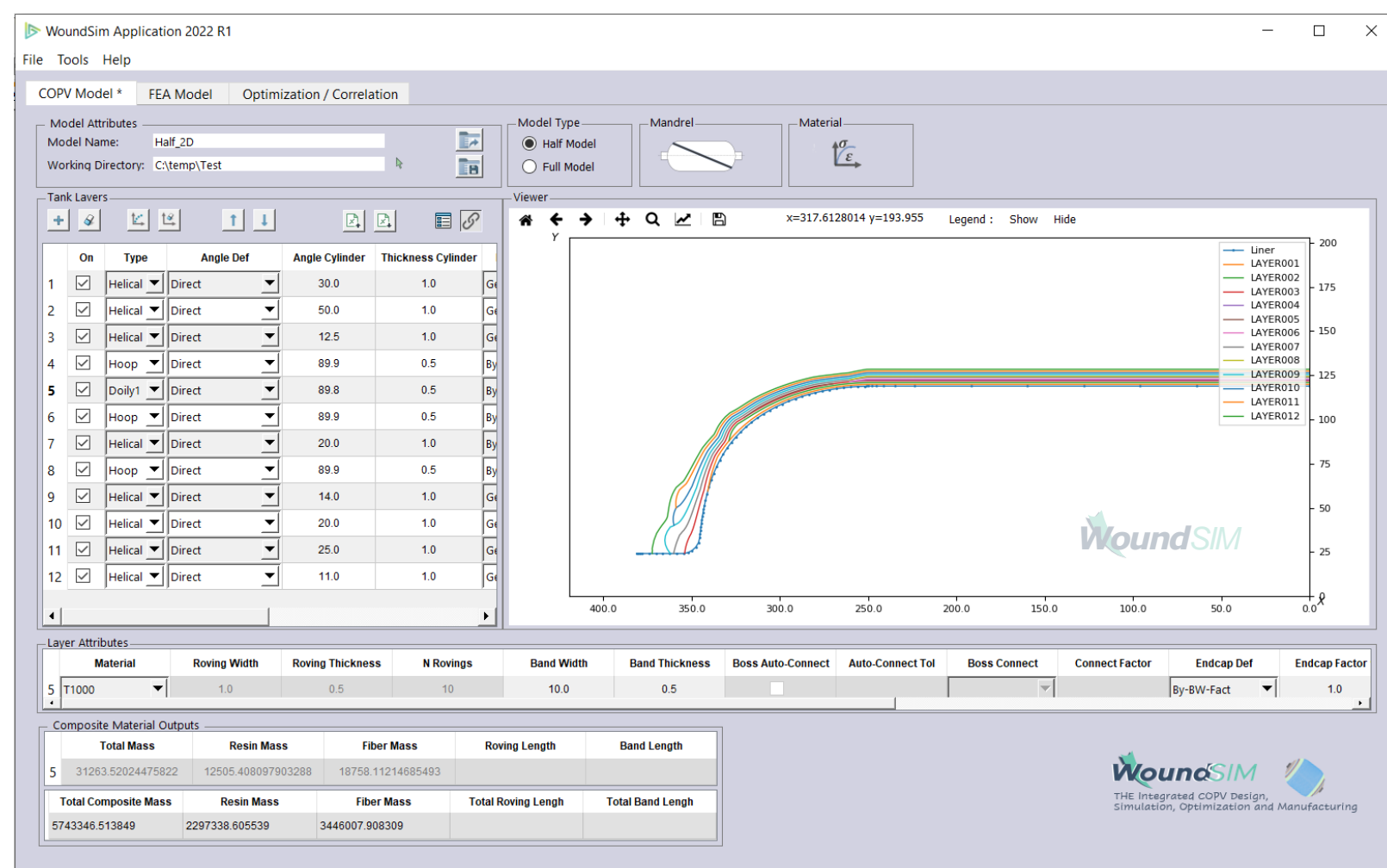
WoundSIM

THE integrated intelligence for composite pressure vessels design and simulation

3D SIMULIA



Overview



GENERAL PRESENTATION

WoundSIM is a next-generation tool used to design, simulate and optimize composite overwrapped pressure vessels (COPVs). A graphical interface is used to instantaneously view the composite layup as the table of the composite layers is defined. Layers thickness buildup is automatically calculated, along with the continuously varying wind angles. Smeared material properties are computed and assigned throughout the COPV.

Thanks to the integrated FEA software translator, a run-ready FEA model can be instantaneously generated to assess the thermal and mechanical responses of the COPV.

PRINCIPLE FEATURES

WoundSIM has a comprehensive feature list to ensure a rapid and efficient tank design process. Most of the important features are listed here:

- ▶ Enhanced layer thickness buildup for better correlation against produced tanks geometry,
- ▶ Comprehensive design parameters allowing a quick variation of layers shape,
- ▶ Democratized tool with a comprehensive and standalone user interface,
- ▶ GUI short time response (<1s for 30 layers),
- ▶ Smart layup rendering allowing easy layer selection and identification,
- ▶ Quick and fully automated tank FE model generation and post-processing,
- ▶ Full compatibility and integration with SIMULIA Abaqus/FEA,
- ▶ Automated Abaqus WCM models conversion,
- ▶ Command line interface and compatibility with optimization software (e.g, Isight)
- ▶ Public XML API to ensure the openness to other winding software or customer's in-house tools and formulations,
- ▶ Integrated tank parametric optimization capabilities to reduce tank weight,
- ▶ Integrated models VS tests calibration



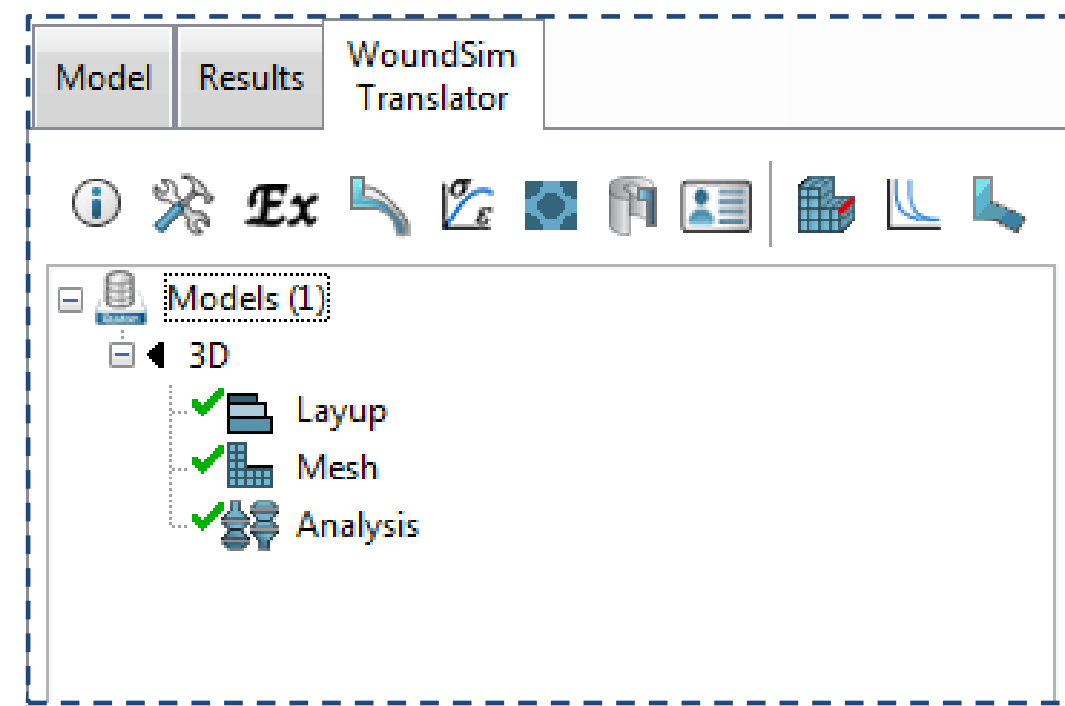
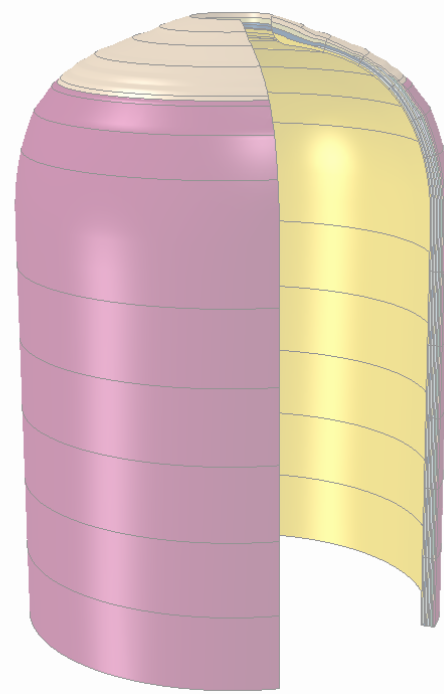
FE Simulation Models

FROM WOUNDSIM TO FEA

After the layup definition and validation in the **WoundSIM** interface, users can generate the reservoir geometry and the corresponding FEA models in order to perform all needed simulations.

Generated models are run-ready and they include:

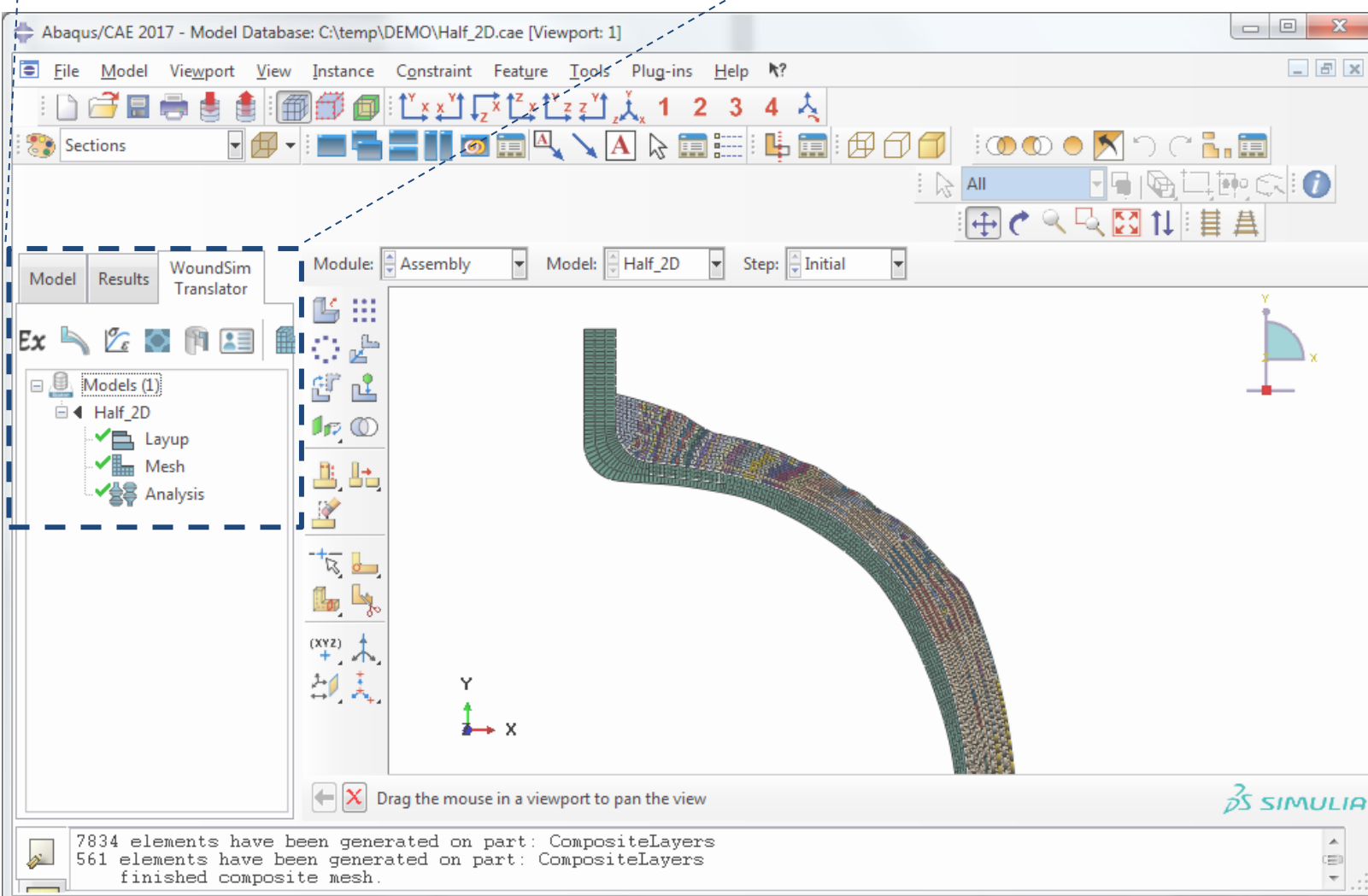
- Tank layer geometry and enhanced reservoir mesh generation,
- Transformed material properties,
- Automated assembly with other reservoir components
- Loads and boundary condition definitions,
- Possibility to generate 2D, 3D, Shell and Solid models,
- Abaqus/CAE model can be edited and enriched by the user,
- Compatibility with Abaqus Implicit and Explicit Solvers



FE ANALYSIS TYPES

Generated FE models allow to run all required load cases to design the tank:

- Static or Dynamic Burst Pressure,
- Heat-Transfer Analysis,
- Coupled Temperature-Displacement,
- Dynamic drop tests and impacts,
- Cyclic and fatigue assessment.



«Courtesy of A & P Technology»

COMPOSITE MATERIALS

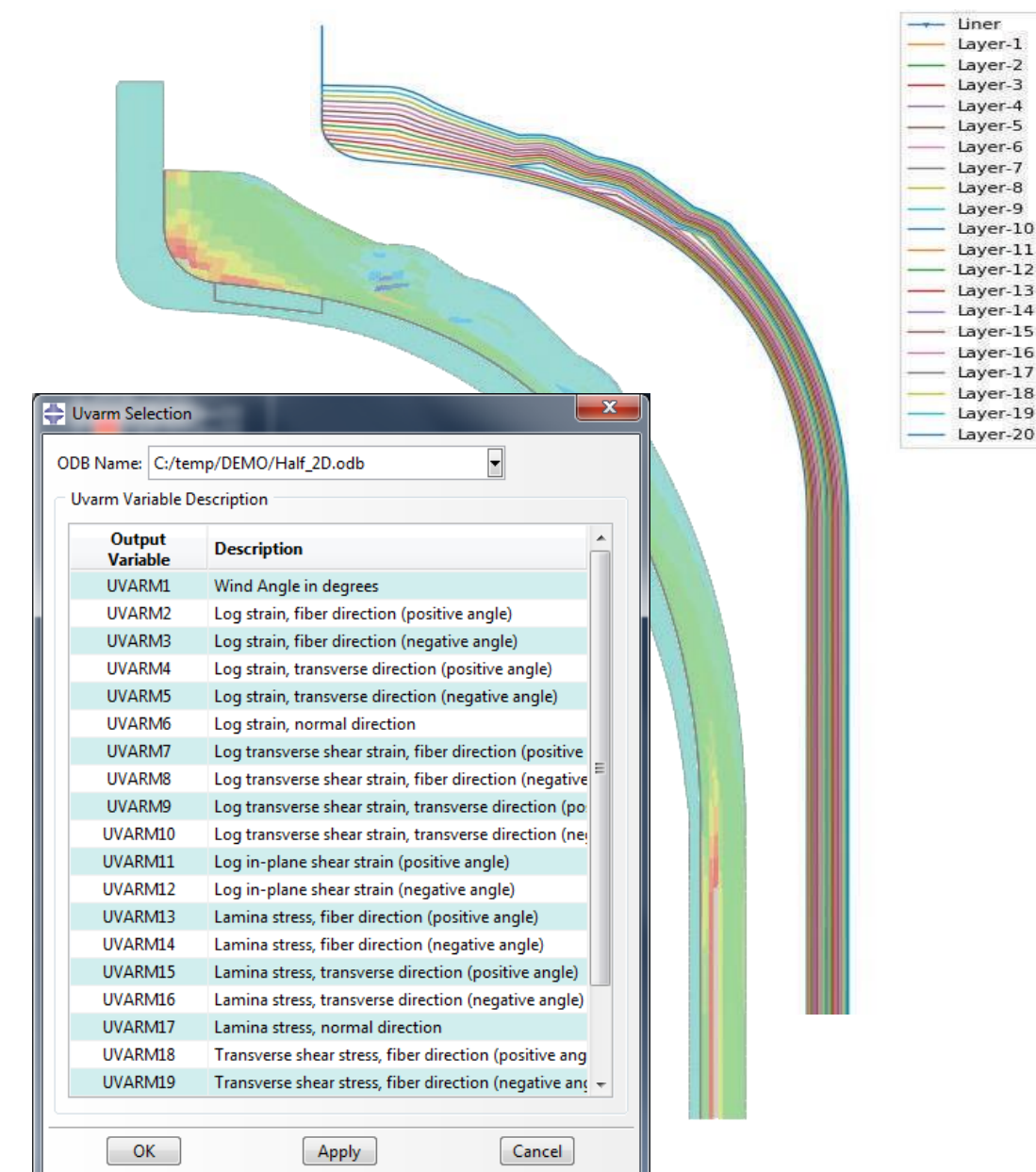
The micro-mechanics module included in WoundSIM allows for the creation of composite lamina materials from fiber and matrix properties.

Fail stress and fail strain parameters can be included in the FE analysis to allow a realistic prediction of the tank material failure using common failure theories (e.g Tsai-Hill, Tsai-Wu ...).

ABAQUS RESULTS

The **WoundSIM-to-Abaqus** interface provides a number of seamless post processing capabilities such as specialized path plotting and contour plotting tools allowing for quick and easy tank response assessment.

WoundSIM includes a compiled user subroutine library that gives access to all composite specific output post-processing quantities such as winding angles, fiber & matrix stresses and strains, damage parameters. Jobs can be executed without a Fortran compiler.



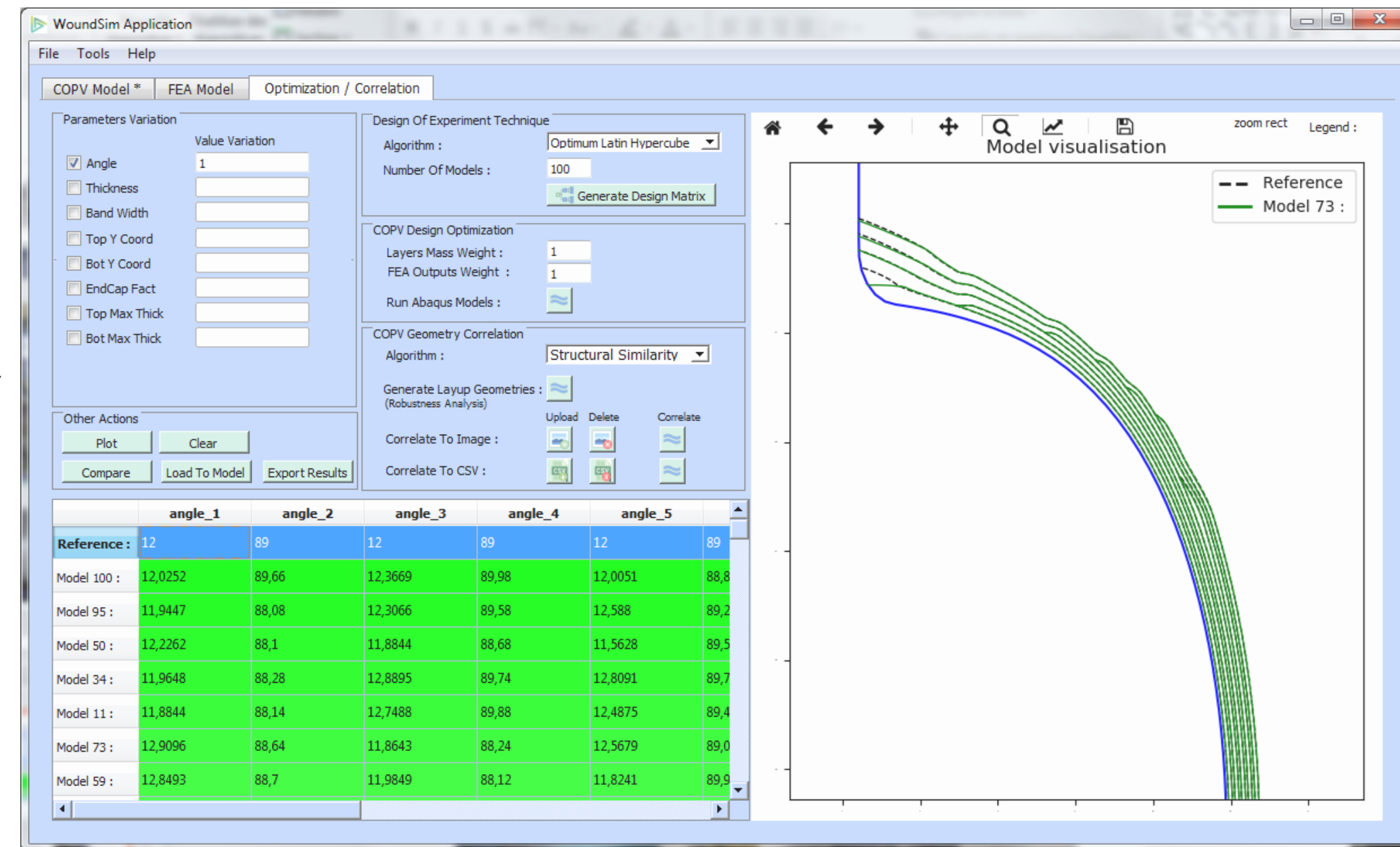
Advanced Features

PARAMETRIC RESERVOIR MODELING

WoundSIM offers advanced engineering capabilities and integrated algorithms that allow several capabilities for composite reservoir designers and simulation engineers.

Some of these capabilities are listed below:

- ▶ Tank weight optimization capabilities allowing up to 30% reduction of the composite mass,
- ▶ Included design of experiment technique algorithms,
- ▶ Finite elements models model batch computing,
- ▶ Reservoir geometry robustness analysis,
- ▶ Model correlation to other winding software or in-house thickness buildup equations,
- ▶ Model correlation with experimental results.

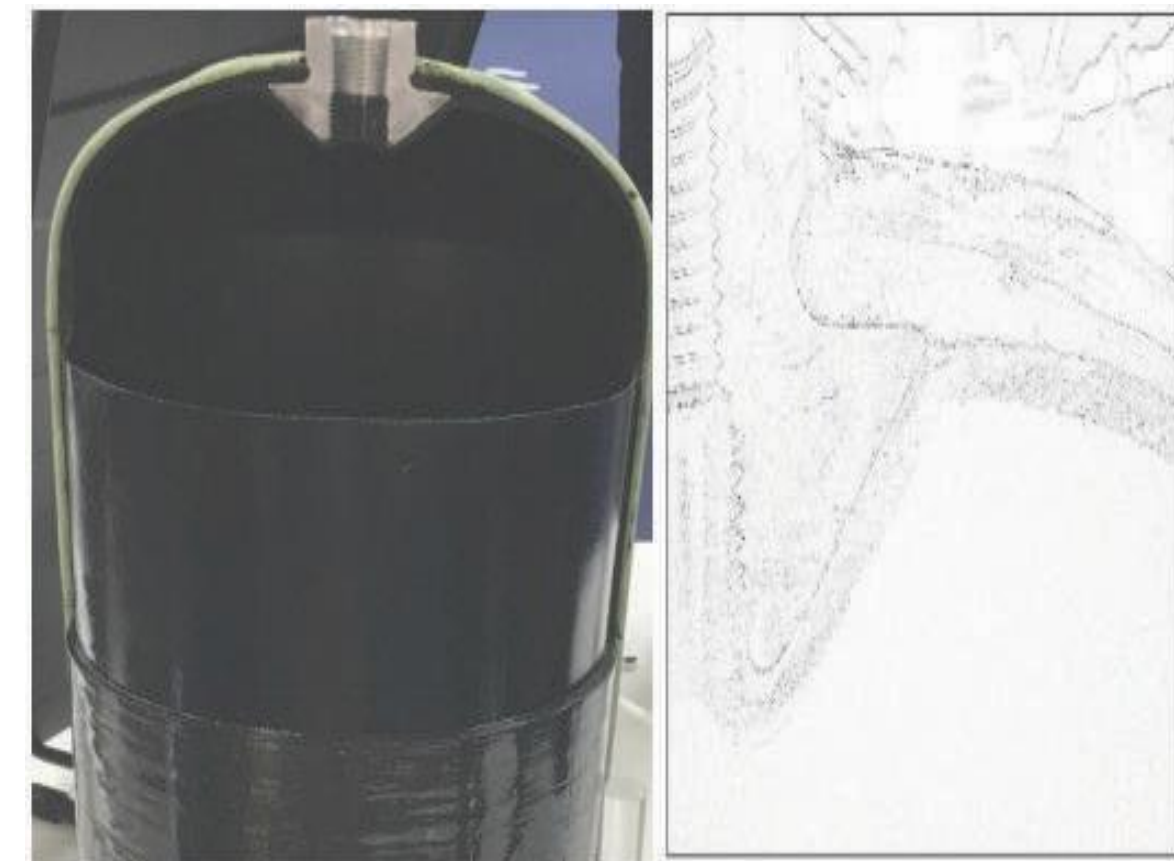


DESIGN OF EXPERIMENT

- ▶ DOE feature allows the analysis of multiple geometry parameters,
- ▶ Analyze the impact of input parameters on the layer's geometry,
- ▶ Analyze the impact of input parameters on the tank response,
- ▶ Allow tank reliability analysis,
- ▶ Allow the selection of better design parameters.

MODEL VS TEST CORRELATION

- ▶ WoundSIM includes automated correlation algorithms between the generated models and the manufactured tank geometry,
- ▶ Usage of intelligent images comparisons.





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