One Piece Hood/Co-Molding Project

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Managed & operated by
Michigan State University

INEOS

CMSC Composites Manufacturing & Simulation Center

PURDUE UNIVERSITY

IDI

MICHIGAN STATE UNIVERSITY

THE COMPOSITES acmi INSTITUTE

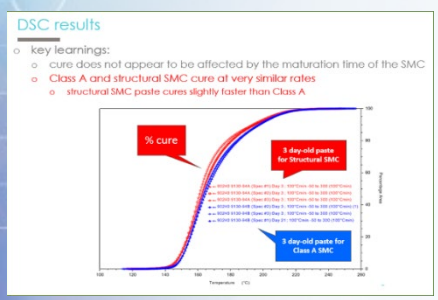
Project Team

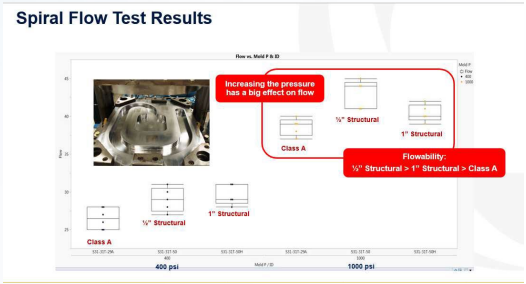
- Volkswagen
- Purdue-CMSC
- MSU-SuRF
- INEOS
- IDI Composites International
- Magna
- E-Xstream

Project Objectives

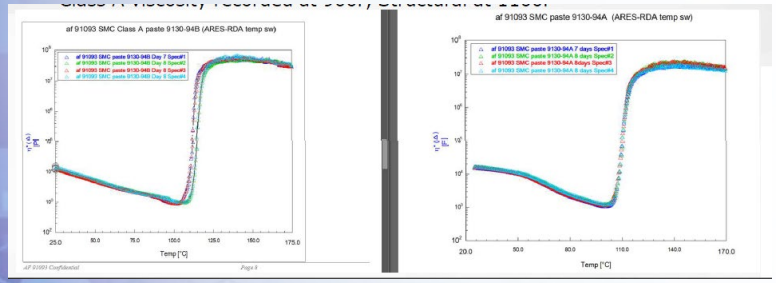
- Multi-material property characterization (Purdue/MSU)
  - Flat and ribbed plaque studies
- Validation of multi-material flow simulation (Purdue/MSU/INEOS)
- Development of a model that can be used to :
  - Determine the amount and placement of the charge of Class “A”, Structural SMC and pre-preg
  - Design feasibility of a one-piece hood
    - Develop a surrogate small scale part

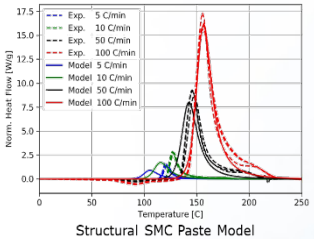
Initial Paste and SMC Characterization



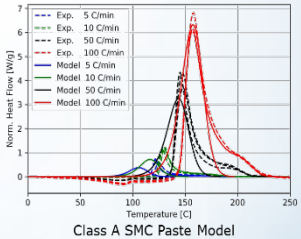


- Cure characteristics and rheology data for the Class A and Structural SMC paste provided by INEOS
- A cure model was developed by Purdue utilizing higher rates of cure (50 to 100C/min), which was used in subsequent models.





Structural SMC Paste Model

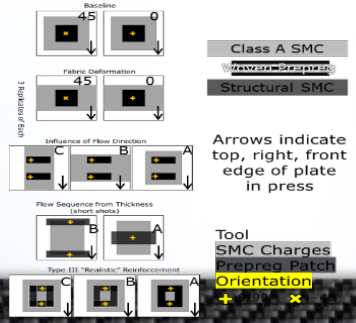


Class A SMC Paste Model

Work by Mike Bogdanor

Flat Plaque Studies

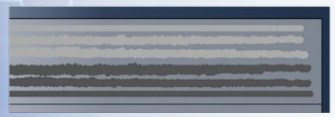
- Flat Plaque Study
  - Materials Used (IDI)
    - Class A SMC: 29% GF
    - Woven Pre-preg: 55%GF
    - Structural SMC: 50% GF 1” and ½” Fiber Varieties
  - Material Combinations:
    - Single Component
    - 2 component (Class A and Structural SMC)
    - 3 component (Class A, woven, structural SMC)
  - Charge patterns



- Results:
  - Mechanical characterization
    - Tensile (RT, 90C, -35C)
    - 4 Point Bend (RT, 90C, -35C)
    - 3 Point Bend (ILS)
  - Non-destructive fiber placement detection
    - Visual Inspection
    - Ultrasonic
    - 2D X-ray
    - Qualisensor Surface Analysis

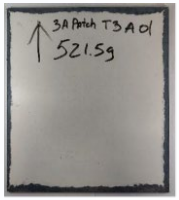
Non-destructive Fiber Placement Testing

Visual Inspection



- 2-material charge initialized
- Each charge sheet 3 "particles" thick

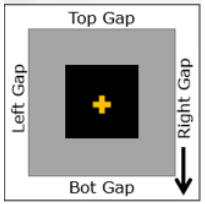
Nearly even fill of both materials

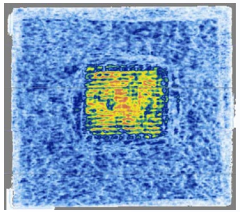


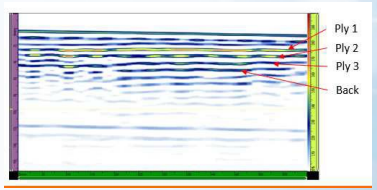
Structural SMC (dark) flow front ahead of Class A, wraps around edge

Simulations by Tony Favaloro

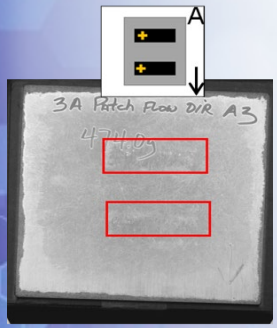
Ultrasonic (UTK)



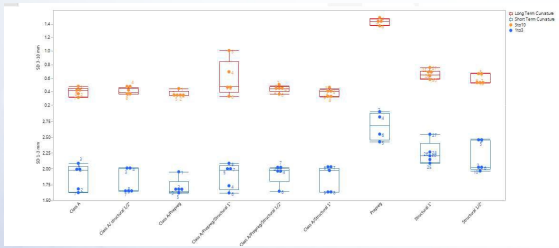




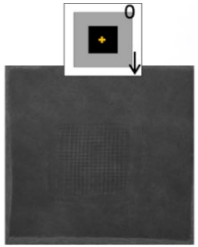
Qualisense Surface Measurement

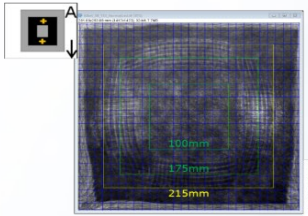


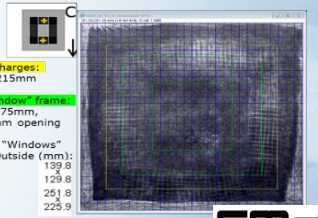
Qualisensor Surface Measurement (INEOS)



2D X-ray (UTK)



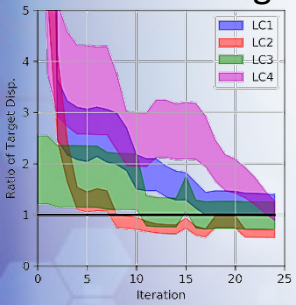


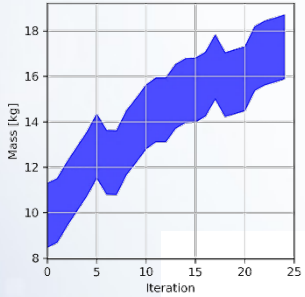


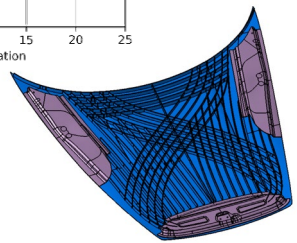
X-ray radiography (UTK)

Development of Small Scale Surrogate Part

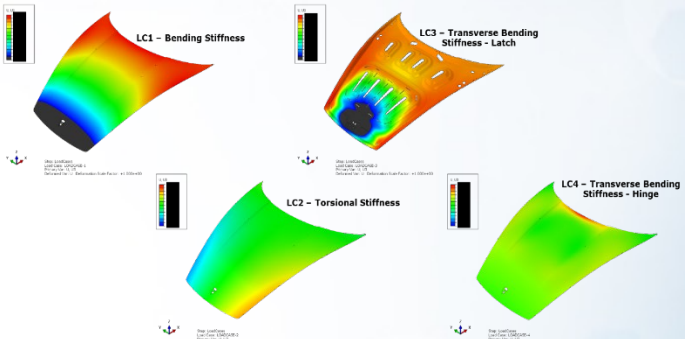
- Target application: Automotive Hood
  - Baseline Al Hood: 8.7kg
  - Optimized one piece composite hood: 16-18kgs
    - 24 optimization iterations performed ranging from no ribs to all “available” ribs



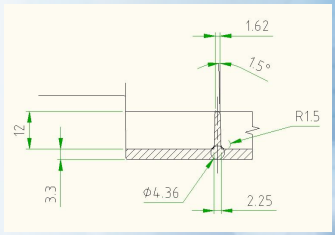


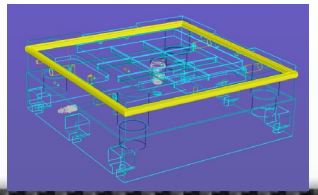


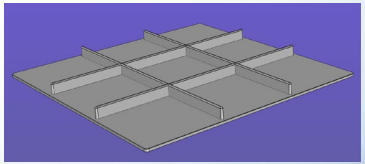
- Load Cases



- Obstacles to surrogate
  - Cost
  - Size restrictions
  - Class “A”







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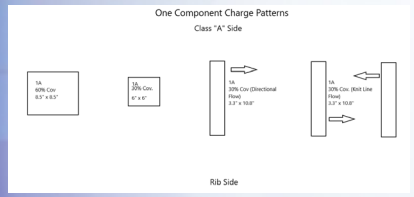
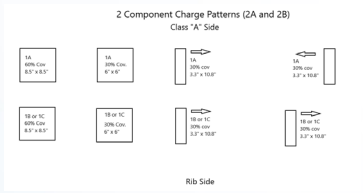
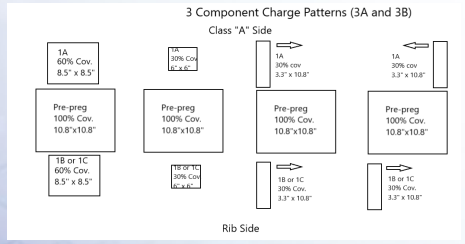
Ribbed Plaque Studies

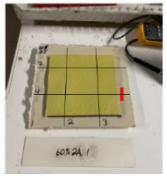
- Materials Used (IDI)
  - Class A SMC: 29% GF
  - Woven Pre-preg: 55%GF
  - Structural SMC: 50% GF 1” and ½” Fiber Varieties
- Charge Patterns

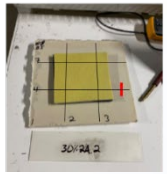


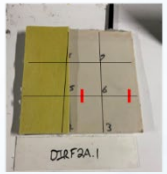




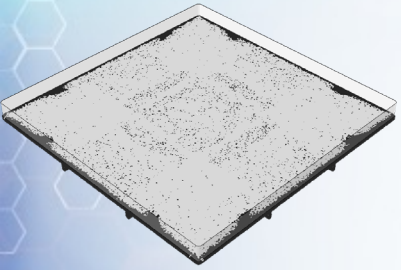
- Results
  - Visual Inspection
  - Surface Analysis (INEOS)
  - Microscopy (MSU/Purdue)
    - Layer Thicknesses
    - Fiber Orientation States
  - Panel Burn-offs (INEOS)
  - CT Scan (1”x1” Sample)

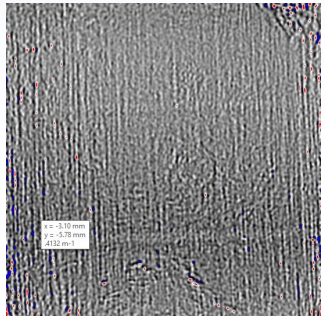




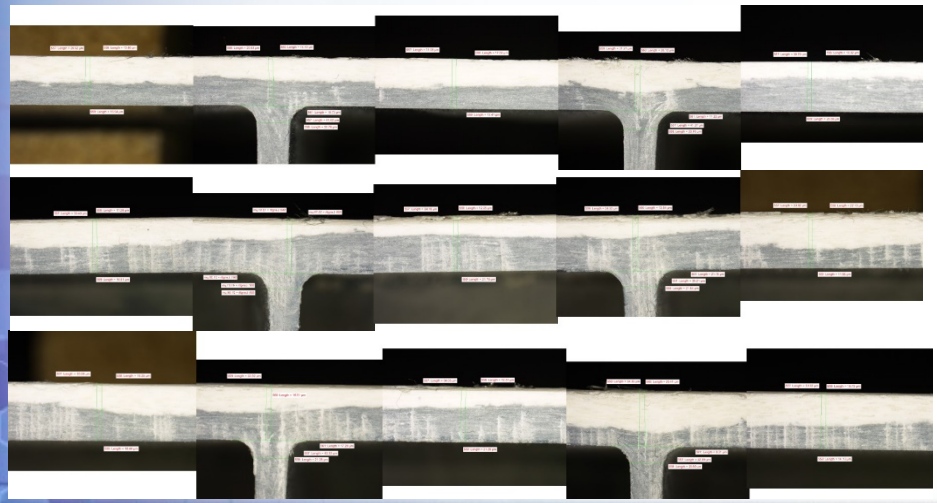


Ribbed Tool Experimental Results (ongoing)





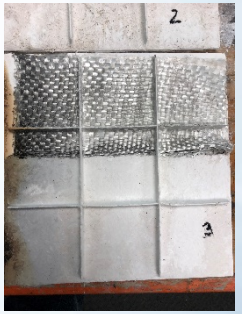
- All plaques sent to project partners 9-28-20
- Characterization testing is ongoing
  - Material interface characteristics
  - CT Scanning



60%3A

30%3A

KNIT3A



DIRF3A

Upcoming Work

- Phase I
  - Evaluate top-coat on flat plaques (Magna)
  - Finish testing on ribbed plaque tool
    - Burn-offs (INEOS)
      - Dissect layers for fiber orientation states
    - Microscopy (Purdue/MSU)
      - Deeper look into material interfaces
    - Finish validation of simulations vs experimental plaques
    - Final Report (Project Team)
- Phase II
  - Requires additional funding for prototype tooling
  - Additional ribbed inserts to test novel ribbed designs
    - AM tooling
  - Additional experiments on ribbed tool
    - Rib-read through reduction
    - Flow optimization
    - Material thickness optimization
  - Explore additional materials to meet required properties
  - Further Flow simulation validation
    - Fiber orientation mapping
    - Predicted Performance

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