SPE Topcon Slides
Probir Guha  Introduction-Background

- Probir retired at the end of 2021 after an illustrious career in the composites industry mostly with companies including The Budd Company, Continental Structural Plastics and Coats.
- Over an almost 50-year career, he has enjoyed leadership positions in various companies
- Where he had an opportunity to work with and learn from some of the best talent in our industry
- Probir is extremely appreciative of being recognized by his peers in 2022 with two prestigious Awards
  - The SPE Automotive’s Lifetime Achievement Award
  - & the ACMA’s Hall of Fame Award
- ‘Retirement’ was short-lived for Probir
- He formed a technology consulting company, Composites Innovations Inc. to continue the pursuit of cost-effective light weight composites & have fun!
Overview

- In the next few minutes, I’d like to share some of my observations about the world of composites over the past several years.
- The experiences I share will be mostly derived from “SMC in automotive” – that is where I have been since grad school!
- But a lot of it can be translated into other material, processes and applications.
- The discussion will be on
  - SMC and applications
  - against an important background of innovations
  - & learning from ‘other’ industries, value-adds to composite products, emerging technologies
- Today I hope to learn from you as well – please do participate in the end where I will seek your feedback on factors that may affect our industry.
The SMC process & Evolution of Applications over 40+ Years
• This process Flow chart has **15 steps**
• If we assume there are **3 factors** that affect each process step
• That would mean that there are **45 factors** that influence the SMC Matrix Compounding Process
• This process Flow chart has **9 steps**
• If we assume there are **3 factors** that affect each process step
• That would mean that there are **27 factors** that influence the SMC Compounding Process
• This process Flow chart has 10 steps
• If we assume there are 3 factors that affect each process step
• That would mean that there are 30 factors that influence the SMC Molding/Painting Process
Over 100 (!) Factors Affect Final Product Quality
Automotive Body Panels

- Composites in automotive body panel applications started around the 70's
- Grill Opening Panels (GOPs) used to be made out of several stamped steel components welded together
- SMC and BMC gradually became the material of choice
- Class 'A' Body Panel grade SMCs entered the market in the mid-80's
- How can thermoset composites offer more than Thermoplastics (vertical panels) & Aluminum?
Automotive & Heavy Truck Body Panels

- Composites in automotive body panel applications started around the 70’s
- Grill Opening Panels (GOPs) used to be made out of several stamped steel components welded together
- SMC and BMC gradually became the material of choice
- Class ‘A’ Body Panel grade SMCs entered the market in the mid-80’s
- How can thermoset composites offer more than Thermoplastics (vertical panels) & Aluminum?
The Pickup Box Revolution

- Ford Sport Trac; Toyota Tacoma; Hyundai Santa Cruz; Toyota Tundra
- The success of SMC Pickup Boxes started in the late ‘90s to early 2000 and continues today
- Advantages cited include weight reduction and corrosion resistance and higher impact resistance
- Could composites offer more?
The EV Battery Cover

- Early success of thermoset composites started after thermoplastic valve covers faced distortion issues
- This early success then led to the first EV Battery Covers from structural SMC
- Innovations in this application continues today
The Future in EV Battery Trays

- **New Challenges**
  - Side Pole Impact
  - Thermal Runaway

- **Old Challenges**
  - Weight
  - Cost

- **Solutions driven by**
  - Continuous fiber
  - Carbon-Glass Hybrid
  - Chemistry for thermal solutions
  - AI-ML being used for ‘rapid learning’
Some Innovations in the Past Five Decades!
Urethane Chemistry in SMC

- **Isocyanate C-side**
- **CA1079890 - Thermosetting Unsaturated Polyester-unsaturated Monomer Filled Composition Comprising Organic Polyisocyanate Metallic (Hydr) Oxide Thickening System**
- **Year - 1980**
- **Objective**
  - Reduce the temperature sensitivity of the SMC paste matrix viscosity during molding
- **Comments** –
  - The work was initiated in 1973 to reduce the temperature sensitivity of the SMC matrix during the molding cycle
  - One of the first use of Urethane and Polyester chemistry in SMC
Vacuum Molding Process

- **Vacuum Molding**
- CA1325704 - Vacuum Compression Molding Apparatus
- US20150360425 - Vacuum Molding Of Thermoset
- **Year** - The Budd Co - 1994 ; CSP - 2015
- **Objective**
  - Elimination of surface porosity
- **Comments**
  - Vacuum molding has been key to the growth of appearance and the pickup box applications
  - Vacuum molding continues to evolve and remains a key part of the SMC molding process
Urethane Chemistry in SMC

- UPE backbone modification (TCA)
- US20050054761 - Reinforced Polyester Resins Having Increased Toughness And Crack Resistance
- Year - 2005
- Objective
  - To eliminate paint defects on molded body panels
- Status & Comments –
  - Significant innovation for painted applications
  - True example of successful industry collaboration – Ford/Budd/AOC
  - Was a natural progression of a 1973 innovation – urethanes in SMC
Surface Treatment to Enhance Adhesion

**Plasma treatment of SMC**

**US20130136929 - Plasma Treated Molding Composition And Process For Modifying A Surface Thereof**

**Year -** 2013

**Objective**
- Obtain a robust consistent molded SMC surface for better adhesion

**Comments –**
- Chemically altering surface chemistry through automation
- Surface chemistry in composites is key – we can expect more to come
Low Density SMC

- **Low Density SMC - Treated Glass Bubbles**
- **US20150376350 - Low-density Molding Compound Containing Surface Derivatized Microspheres**
- **Year - 2015**

**Objective**
- A lower density Class ‘A’ SMC – for a better lightweight solution

**Status & Comments** –
- Developed chemistry to **improve the bonding between the bubble and the matrix** and improved mechanical properties
- Brought **SMC performance to the level of Aluminum**
Use of Continuous Fiber

- **Multiple TFP patents**
- **US20210008816 - Multiple Layer Article With Interactive Reinforcements Linear Ribbon Fiber Reinforcement For Composite Forms**
- **Year - 2021**
- **Objective**
  - Process to develop a ‘cost effective’ process to make near net-shape preforms using multiple fibers in multiple directions
- **Comments –**
  - Continuous *Fiber handling technology from Textiles* (ZSK; Coats)
  - Chopped to *continuous directed fiber is a significant gain of mechanical properties*
Smart Composites

- **Value-Added Composites**
- US20210402719 - Vehicle Component Based On Selective Commingled Fiber Bundle Having Integral Electrical Harness And Embedded Electronics
- US20210053304 - Selective Commingled Fiber Bundle Preform Having Integral Optical Fiber Strain Sensor

- **Year** – 2021
- **Objective**
  - Incorporate conductive paths, embedded electronics or optical fiber on a preform

- **Comments** –
  - This allows for the molded component to have **properties without any additional secondary component or major post-mold operation**
  - **Emerging technology** – there will be more
Challenges and Opportunities Ahead
Challenges and Opportunities

- Challenges - three eternal hurdles
  - Cost
  - Weight
  - Sustainability

- Opportunities – new horizons
  - Use of Continuous Fibers
  - Use of AI-ML
  - Value-Added use of embedded Electronics
We want low weight @ low cost!

Metals
- Steel (1); Aluminum (3) & Magnesium (4)

Chopped Fiber Composites
- GF-SMC (2); CF-SMC (5)

Continuous Fiber Composites
- Conventional CF (6); GF-TFP (7); CF-TFP (8)

Continuous Fiber composites & Multi-Material is the way to go!
Sustainability Challenges

First US steel plants powered by wind, solar energy are coming for industry with big carbon footprint

The steel industry has a massive carbon footprint, as much as 6% to 7% of the world’s greenhouse gas emissions, according to a Rocky Mountain Institute study. A new Nucor steel microplant in Missouri is trying to put a dent in that number.

Metals are showing progress! Can we show progress in thermosets?

GLOBAL PLASTIC PRODUCTION AND WASTE GENERATED BY SECTOR

SMC Waste Streams

- Typical manufacturing process – waste streams in red
- Eliminate or re-use waste
- For effective recycling we require knowledge on
  - Post Consumer Collection streams for composites
  - Separation technologies for end-of-life composite parts
  - Economically viable recycle methods for composites
Challenges and Opportunities

- Challenges - three eternal hurdles
  - Cost
  - Weight
  - Sustainability

- Opportunities – new horizons
  - Use of Continuous Fibers
  - Use of AI-ML
  - Value-Added use of embedded Electronics
A Continuous Fiber Product Possibility

- Design & shape complexities difficult for stamped metals
- Continuous Fibers improve stiffness for composites
- Multi-material possibilities provide additional gains
- Cost effective use of continuous fiber is important
Co-Molding: Integrate Prepreg, TFP & SMC

Key Elements exist today – Can we bring them together in one application?

Sheet Molding Compound (SMC)
- SMC is the paste that is compression molded
  - 35% polyester resin and styrene, which polymerizes and crosslinks
  - 35% glass fibers (1" fibers)
  - 33% Calcium Carbonate
AI/ML Techniques Possibilities

• **Continuous collection** of manufacturing data - numeric, alphanumerical and image
• Past data can be used by Practitioner to **create rules using statistical/machine learning algorithm**
• The **continuously improving algorithm** controls the manufacturing process
• Improves quality & Productivity on a **continuous basis**
• Same methods are being applied to:
  • Manufacturing
  • Sales Analysis
  • Payables analysis
AI to Quantify Cross Section of a Composite

- An example to demonstrate AI-ML in composites
- Use ML to learn the images of the key ingredients in a cross section
  - Fibers; Fillers; Resin; Porosity; etc.
- Develop an Algorithm & quantify each individual image
- The entire ML & Algorithm development took 7 days to develop
Can We Use AI/ML For Real Time Process Improvement?

- Process improvement efforts to improve throughput have been based on Statistical data gathering and analysis techniques
- Challenges faced with current methods: Methods are **time consuming**
- The industry is ready for new techniques: Rapid systems based on **Artificial Intelligence and Machine Learning**
- For **real time improvements** on the shop floor
Smart Composites with Molded Conductive Paths

- Smart automotive Liftgates are in use today
- Uses a post-mold addition of the ‘smart’ component to the assembled liftgate
- Composites are now able to **mold in conductive paths**
- **Can this innovation be used to impart ‘smart’ capabilities** without the use of significant secondary parts?
- **Cost and Weight reduction** opportunity
The Quiz!
A Questionnaire

- Please Participate!
- There are no correct or incorrect response
- There are 5 ‘Multiple Choice’ questions
- And 5 ‘Yes-No’ questions
- Respond with a show of hands
  - Again, there are no correct or incorrect response
  - And your response is important
- Responses will be collected and shared with the conference participants
SMC (Composites) is the material of choice because it is the...

- (1) Best Light Weight solution
- (2) Best Tooling cost solution
- (3) Offers the most Design flexibility
- (4) Best for corrosion resistance
- (5) None of the above
The biggest challenge to thermoset composite sustainability is ..... 

- (1) Inadequate end-of-life collection systems
- (2) Inadequate technology for reuse of waste stream
- (3) Market is not demanding a sustainable product
- (4) Meaning of sustainability is not clearly defined
- (5) None of the above
To be more competitive the SMC (Composites) industry should focus on....

- (1) Increasing R&D efforts  Materials, Process & Design innovations
- (2) Increasing focus on reducing Cost of Poor Quality (COPQ)
- (3) Reduction of production cycle time (button to button)
- (4) Improving Customer Relationship
- (5) Other
SMC faces the stiffest competition from...

- (1) Stamped Steel
- (2) Stamped Aluminum
- (3) ‘Other’ composite materials
- (4) Thermoplastic injection molding
- (5) None of the above
My production process of choice is ....

- (1) Injection molding
- (2) Compression molding
- (3) Resin Transfer Molding
- (4) Liquid Compression Molding
- (5) None of the above
The SMC (Composites) Industry adequately embraces/implements new technology

☐ Yes

☐ No

☐ Not Sure
We have adequate Industry-University technical partnerships in the SMC (Composites) Industry

☐ Yes

☐ No

☐ Not Sure
We have adequate Industry-Customer technical partnerships in the SMC (Composites) Industry

☐ Yes

☐ No

☐ Not Sure
To remain viable the SMC (Composites) industry will need a cost effective sustainability solution by 2027

- Yes
- No
- Not Sure
Styrene is being recycled from end-of-life polystyrene

- Yes
- No
- Not Sure
Some Final Comments

- The world of composites continues to evolve
- We must define the challenges ahead
- & hold on to the inherent strengths of composites
- We have proven that we can adapt, that we are versatile and that we can innovate
- This is a good time to be in composites
- Thank you very much!