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

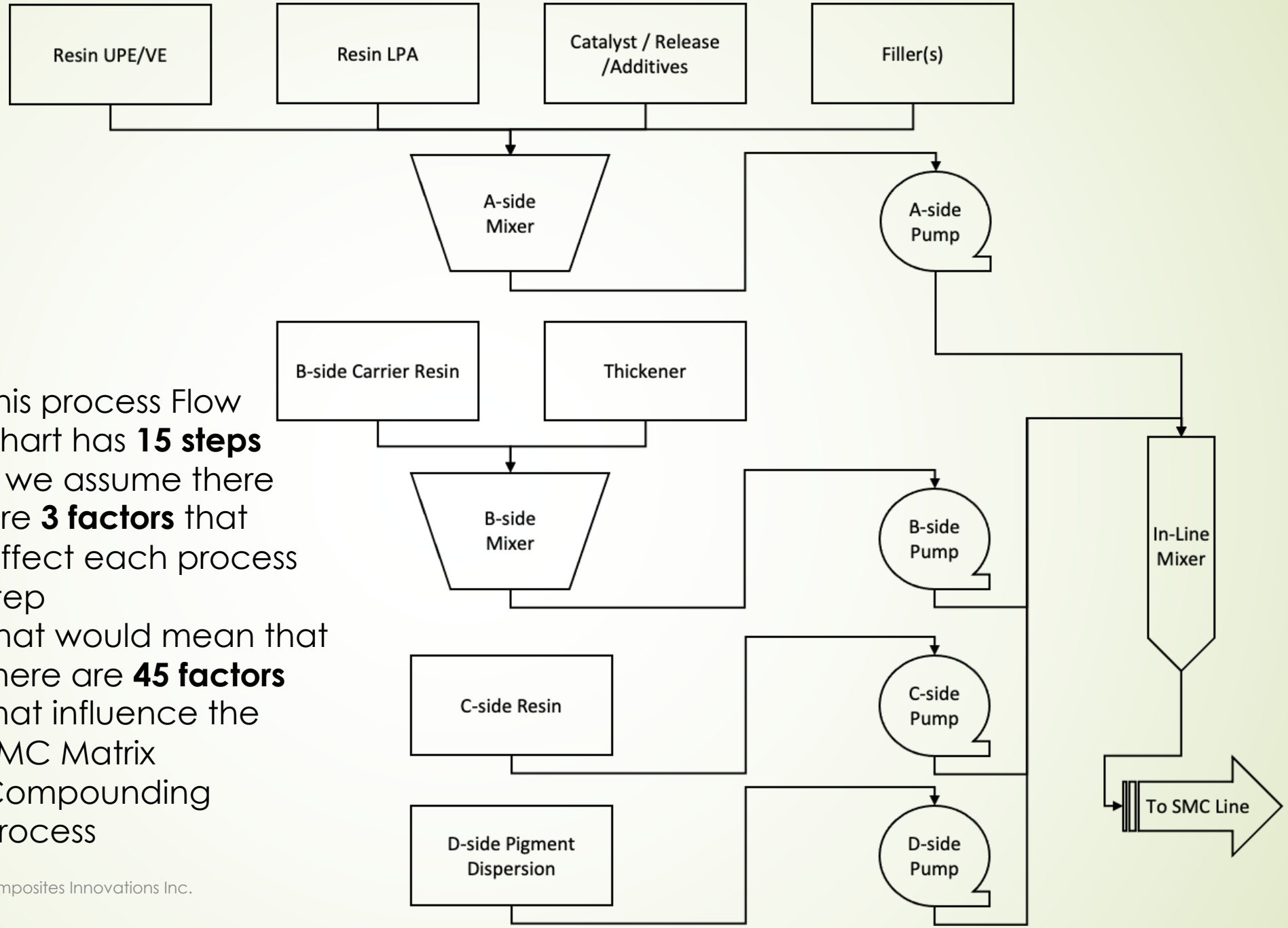
- In the next few minutes, I'd like to share some of my observations about the world of composites over the past several years
- The experiences I share will be mostly derived from "SMC in automotive" – that is where I have been since grad school!
- But a lot of it can be translated into other material, 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

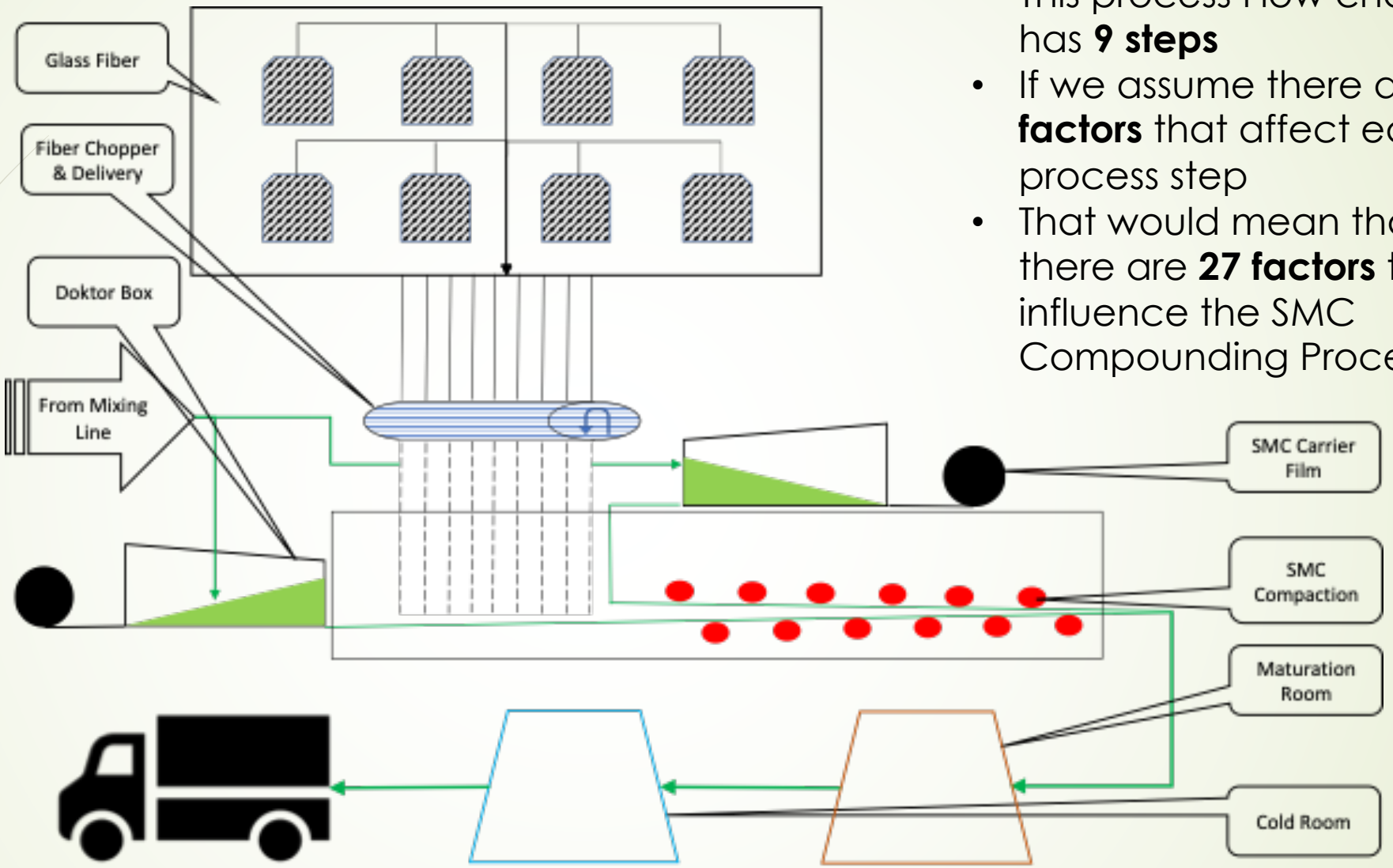
Paste Compounding Process

- 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

3*15 = 45 !!



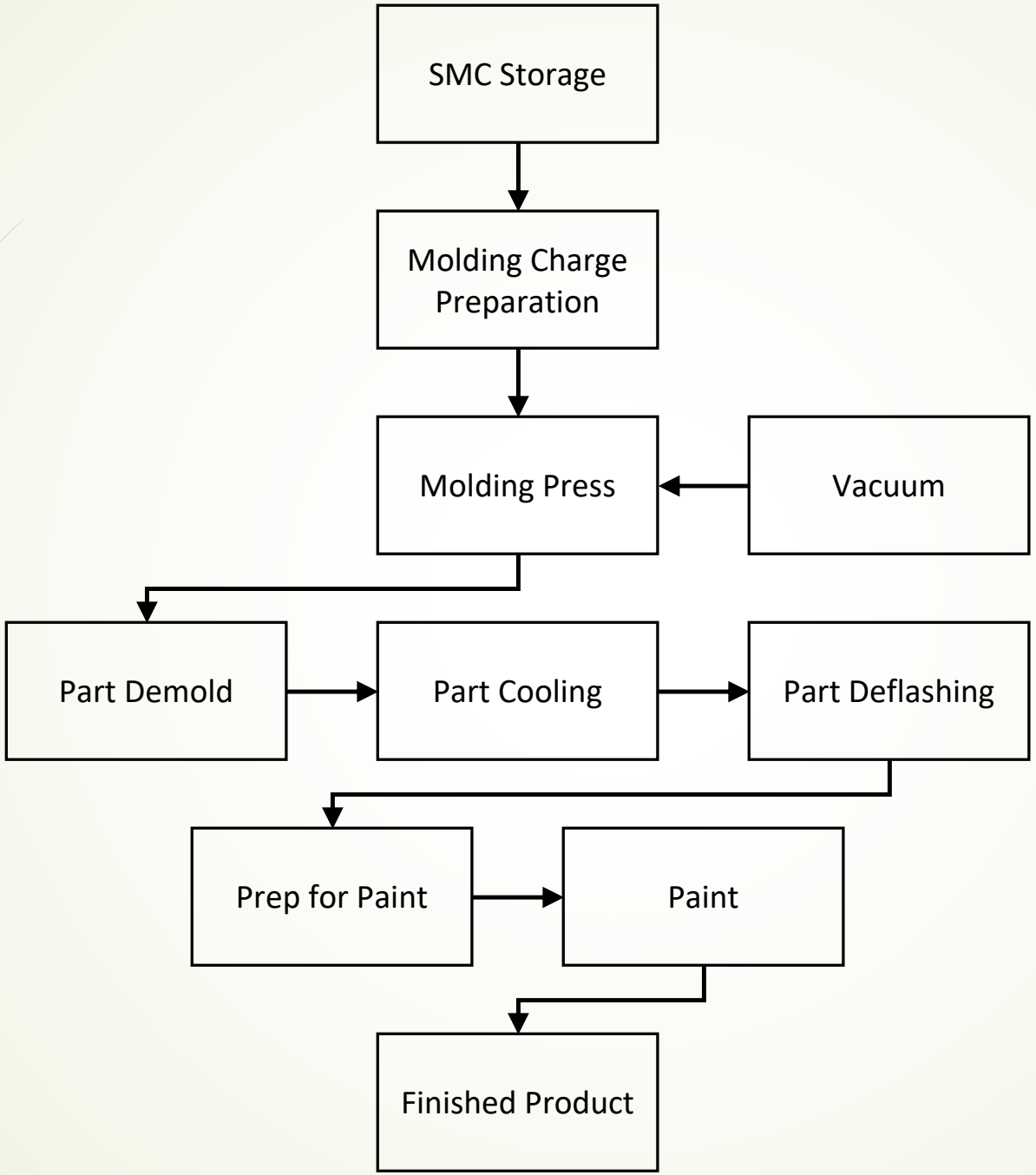
SMC Compounding Process



- 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

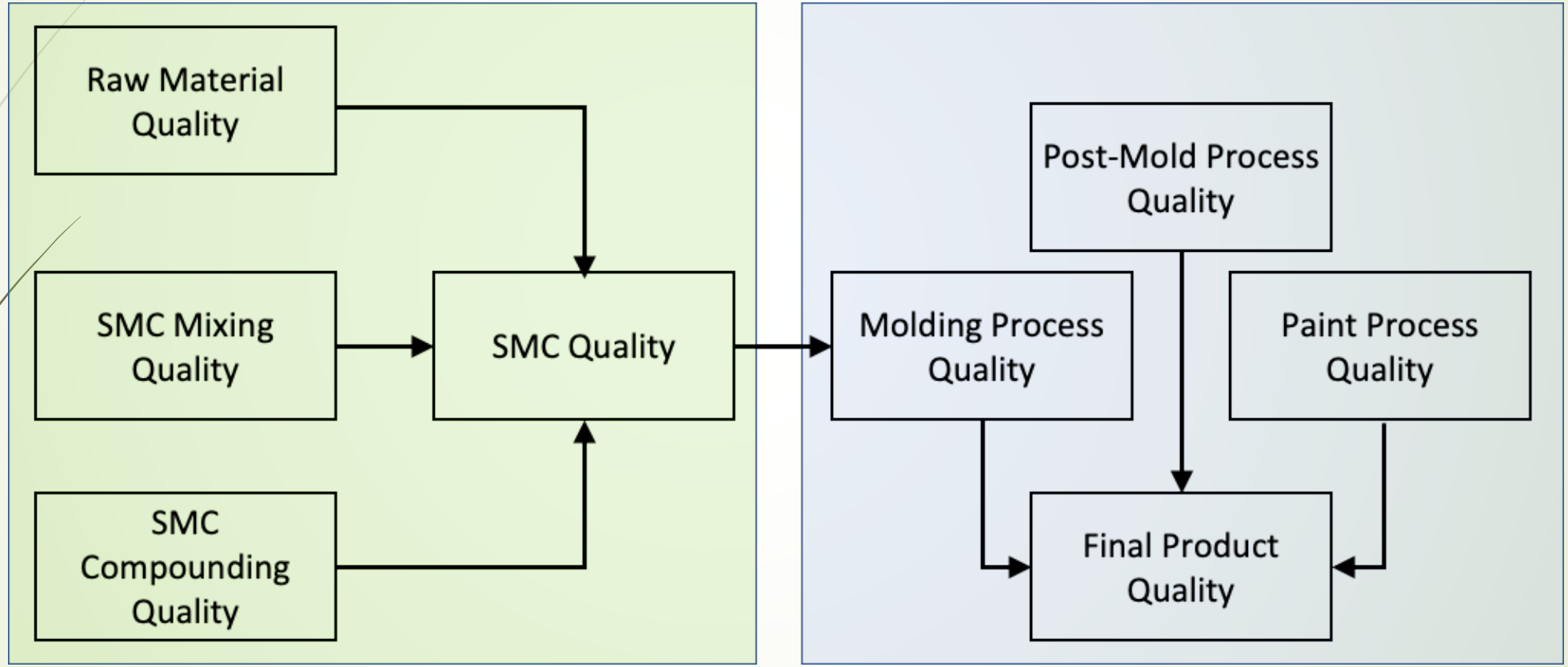
3 * 9 = 27 !!

SMC Molding/Painting 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

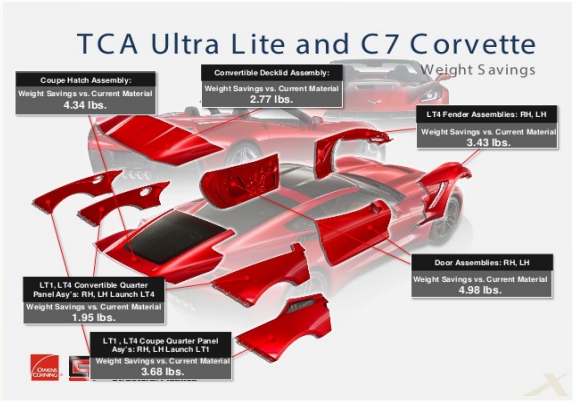


Automotive Body Panels

Consider other pictures

General Motors Medium Duty Truck Body Panels

Mustang Hood & Decklid



Corvette Body Panels

- Composites in automotive body panel applications started around the 70's
- Grill Opening Panels (GOPs) used to be made out 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

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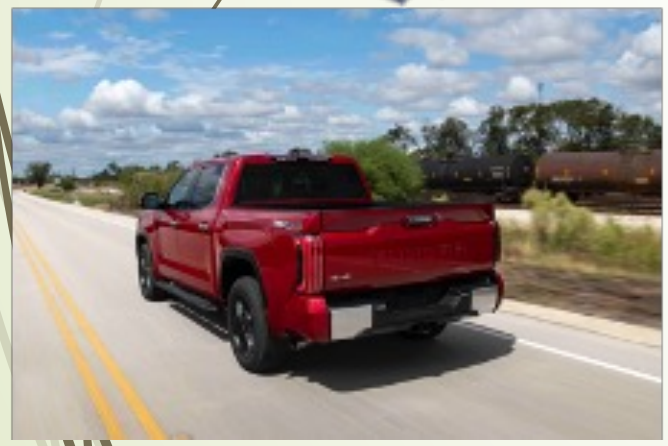
- Class 'A' Body Panel grade SMCs entered the market in the mid-80's
- **How can thermoset composites offer more than Thermoplastics (vertical panels) & Aluminum**?

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**?

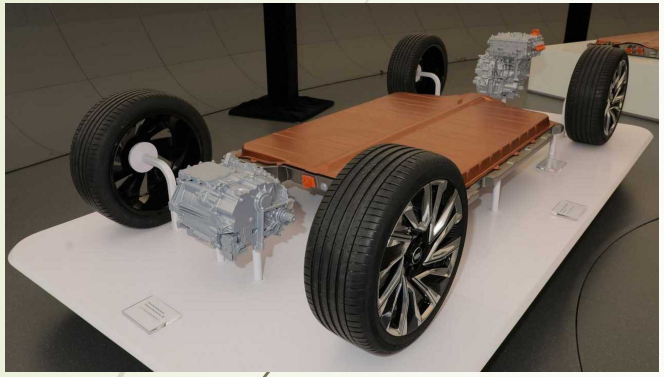
The EV Battery Cover

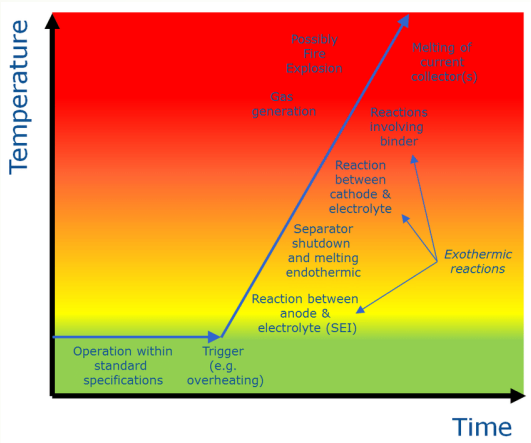
Chevrolet Volt Battery Cover

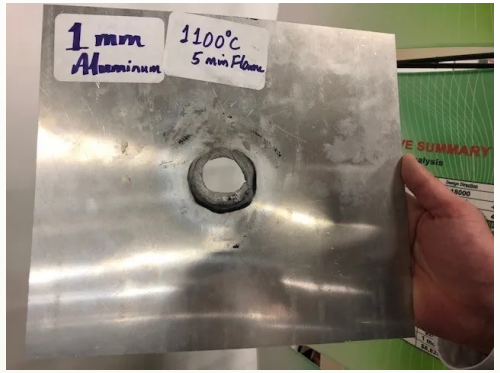
Chevrolet Spark Battery Cover

- 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





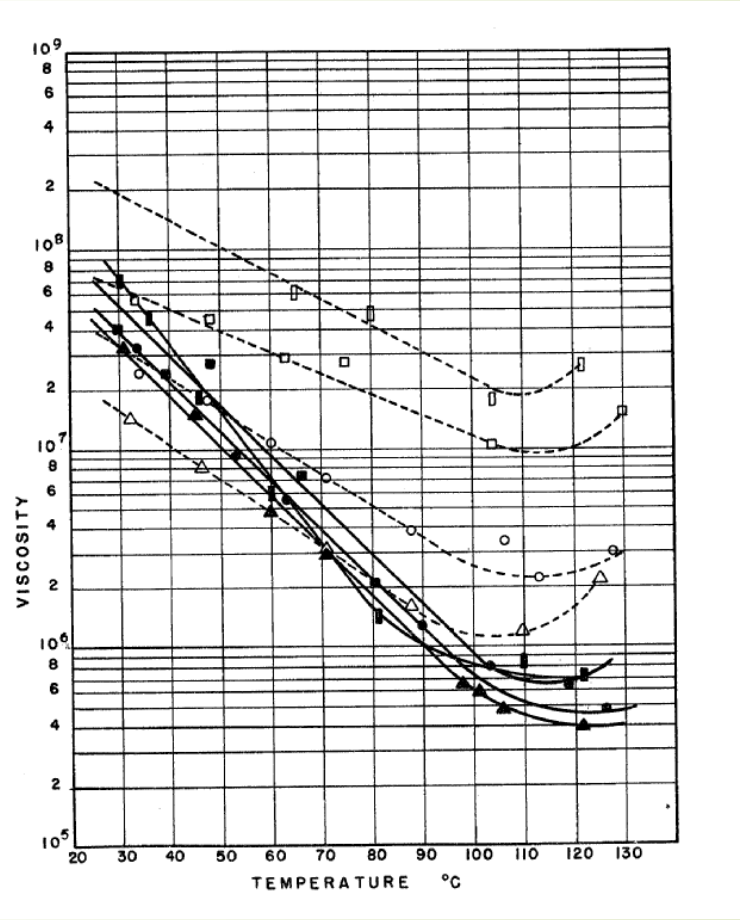


- New Challenges
  - **Side Pole Impact**
  - **Thermal Runaway**
- Old Challenges
  - Weight
  - Cost
- Solutions driven by
  - Continuous fiber
  - Carbon-Glass Hybrid
  - Chemistry for thermal solutions
  - AI-ML being used for ‘rapid learning’

Some Innovations in the Past Five Decades!

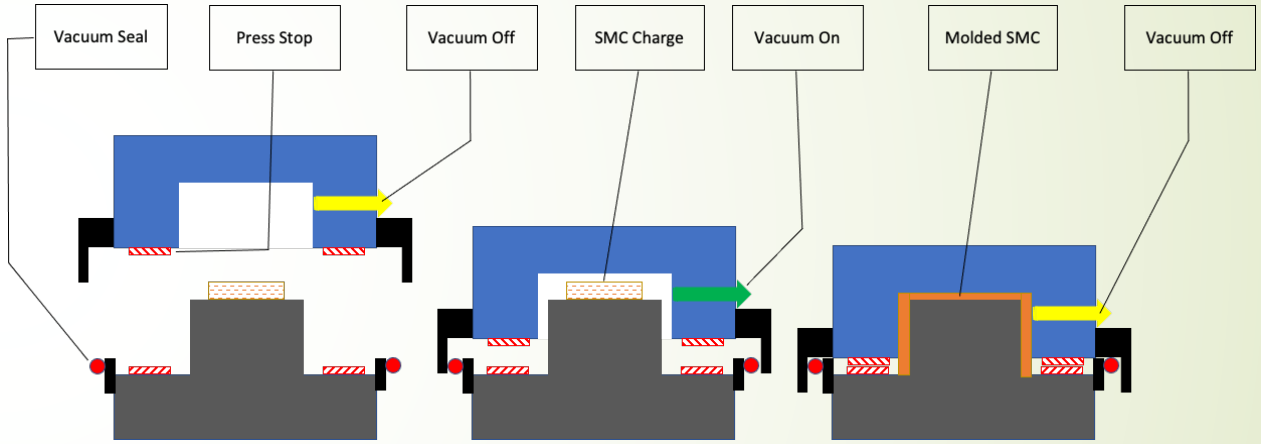
Urethane Chemistry in SMC

- **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**



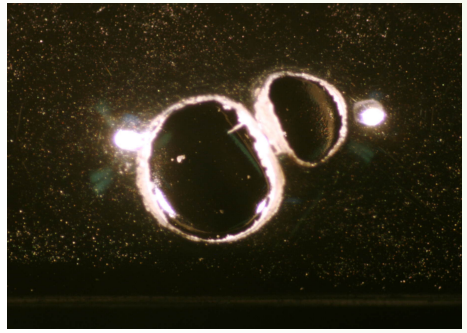
Vacuum Molding Process

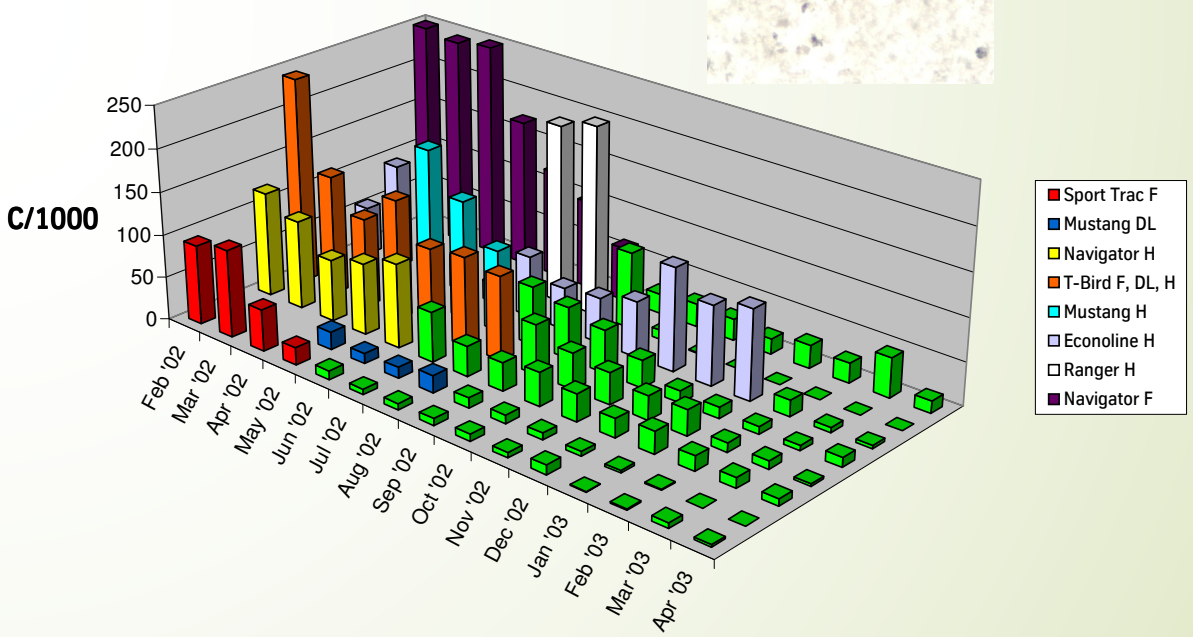
- **Vacuum Molding**
- CA1325704 - Vacuum Compression Molding Apparatus
- US20150360425 - Vacuum Molding Of Thermoset
- **Year** - The Budd Co - 1994 ; CSP - 2015
- **Objective**
  - Elimination of surface porosity
- **Comments**
  - **Vacuum molding has been key** to the growth of appearance and the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



Urethane Chemistry in SMC

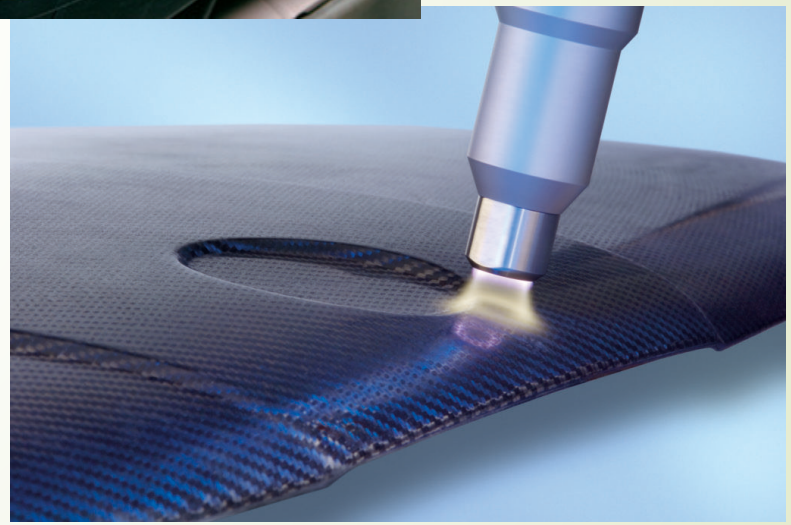
- **UPE backbone modification (TCA)**
- US20050054761 - Reinforced Polyester Resins Having Increased Toughness And Crack Resistance
- **Year -** 2005
- **Objective**
  - To eliminate paint defects on molded body panels
- **Status & Comments** –
  - Significant **innovation for painted applications**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





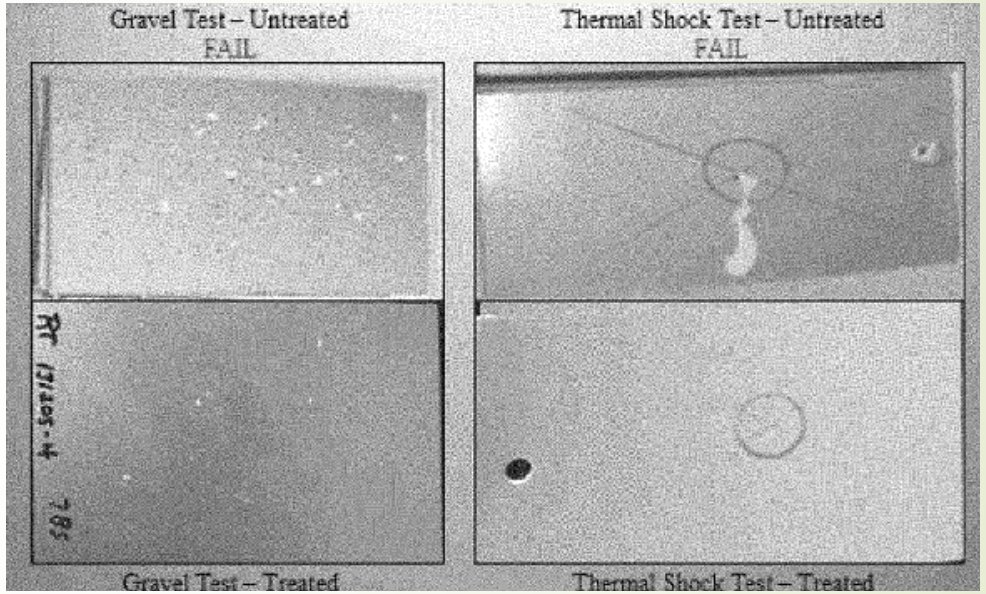
Surface Treatment to Enhance Adhesion

- **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**

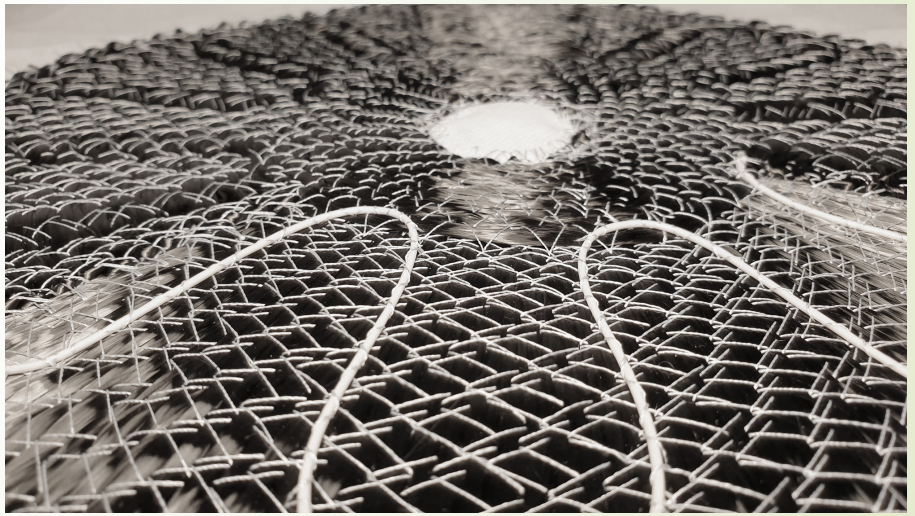


Use of Continuous Fiber

- **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

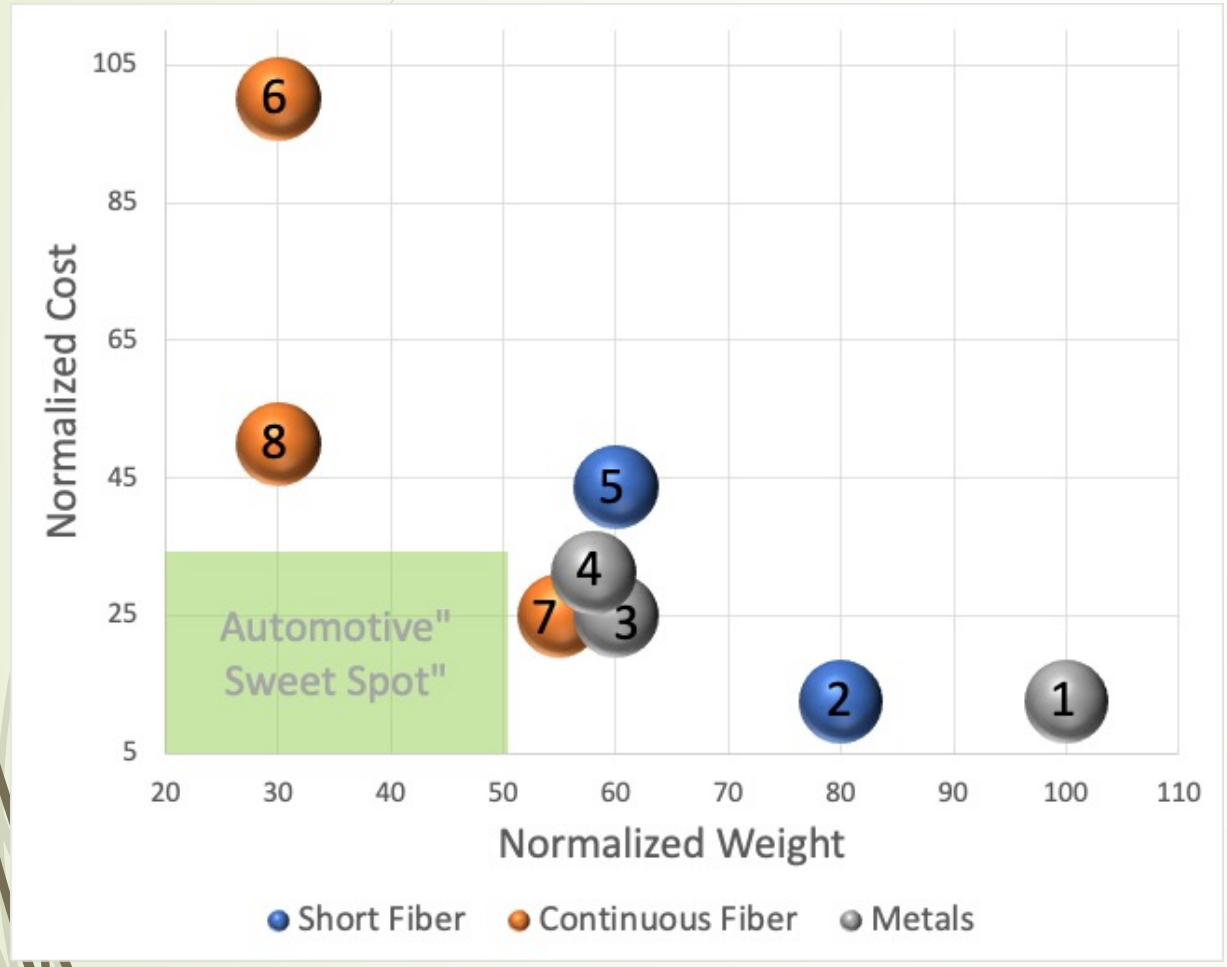


Challenges and Opportunities Ahead

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

Weight vs. Cost Scenario



- 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**!

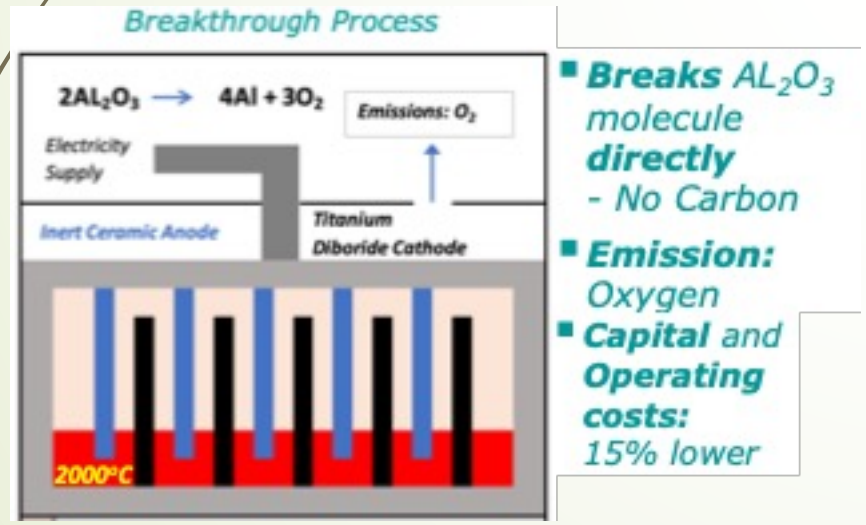
Sustainability Challenges

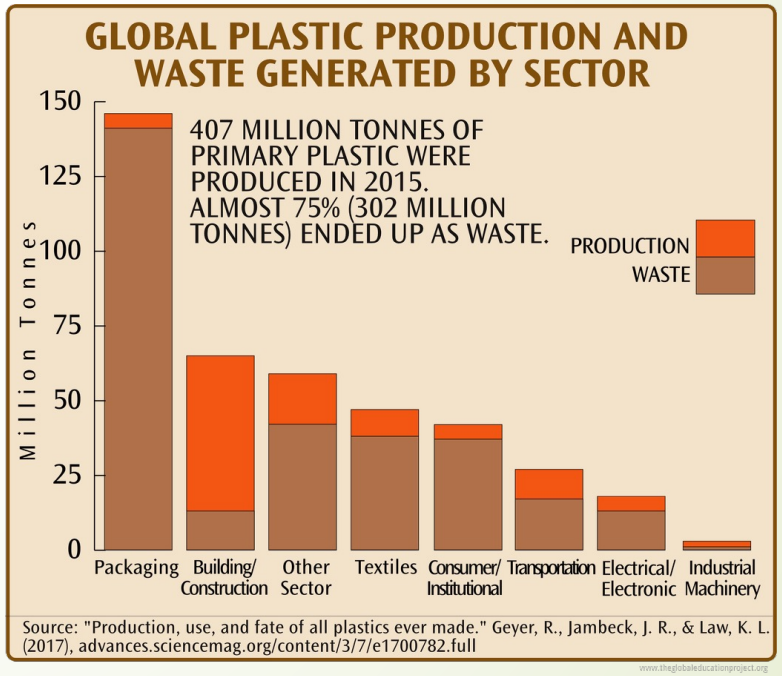
First US steel plants powered by wind, solar energy are coming for industry with big carbon footprint

PUBLISHED SAT, DEC 7 2019-10:30 AM EST | UPDATED SAT, DEC 7 2019-10:31 AM EST

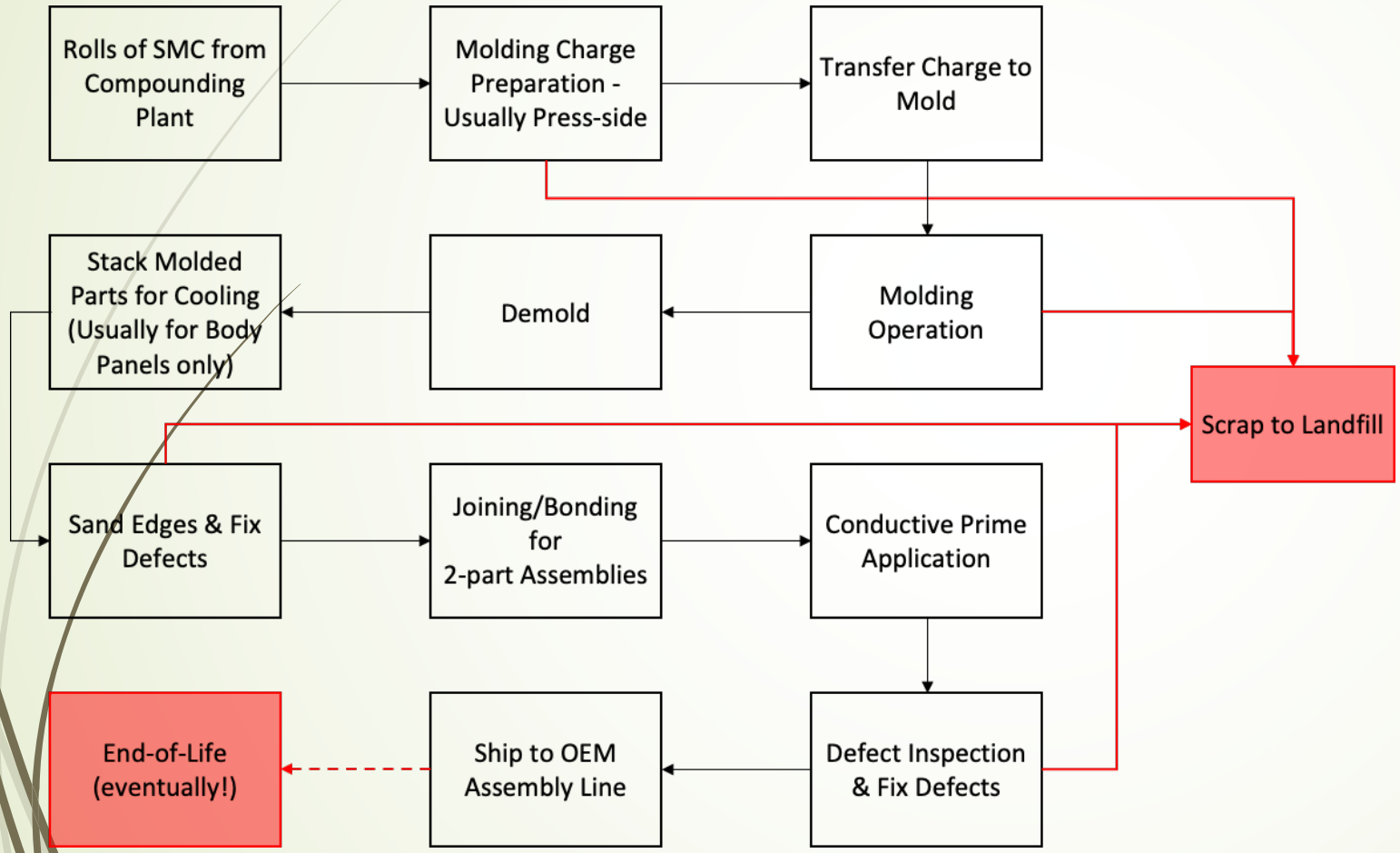
The steel industry has a massive carbon footprint, as much as 6% to 7% of the world's greenhouse gas emissions, according to a Rocky Mountain Institute study. A new Nucor steel microplant in Missouri is trying to put a dent in that number.

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





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
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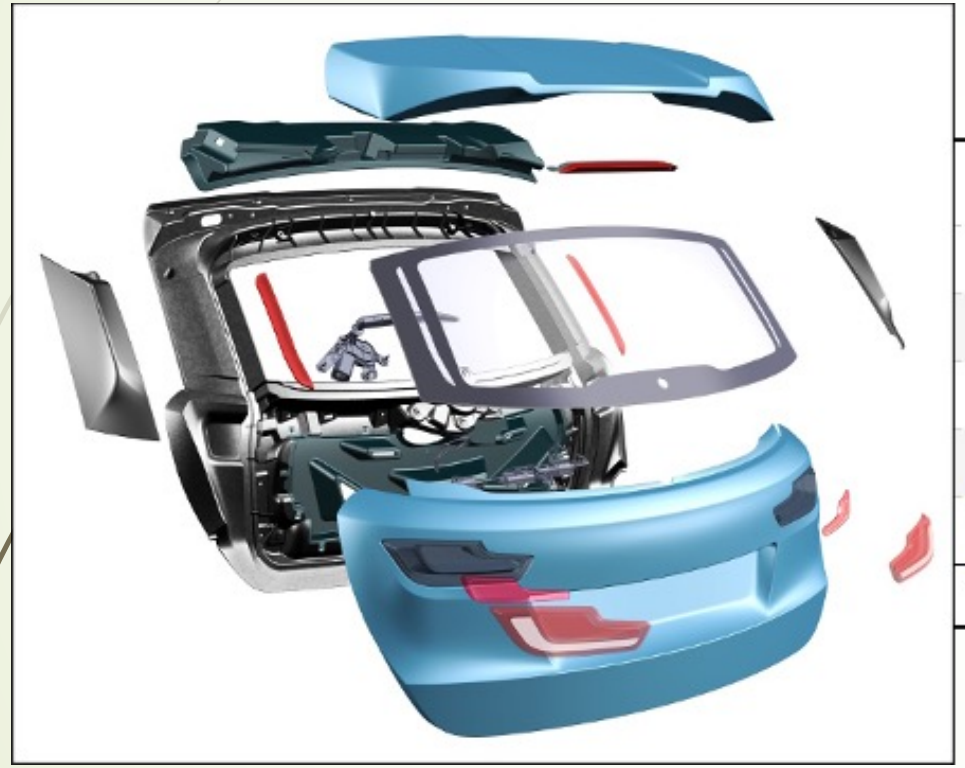
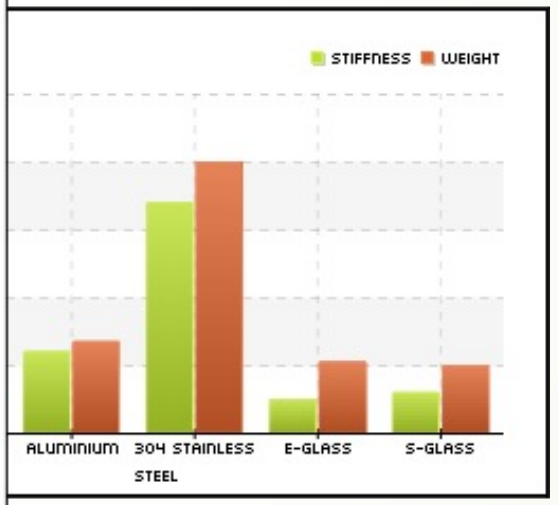
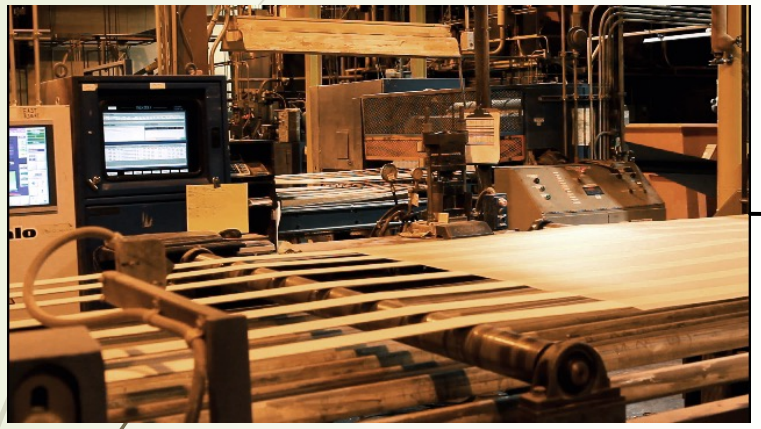
A Continuous Fiber Product Possibility



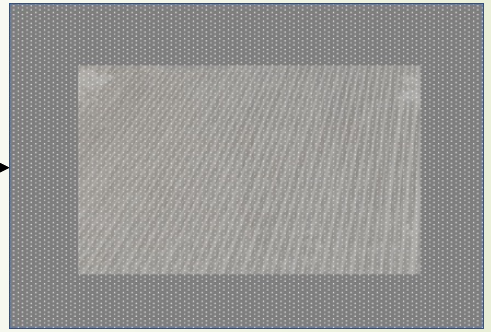


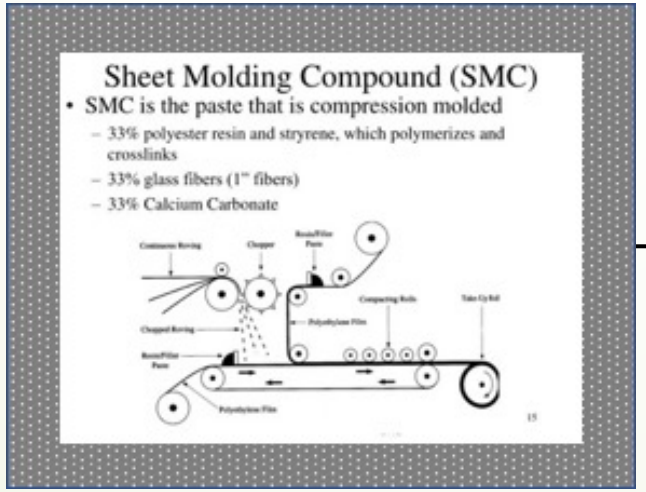
- Design & shape complexities **difficult for stamped metals**
- Continuous Fibers **improve stiffness** for composites
- **Multi-material possibilities** provide additional gains
- **Cost effective** use of continuous fiber is important

Co-Molding : Integrate Prepreg, TFP & SMC



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

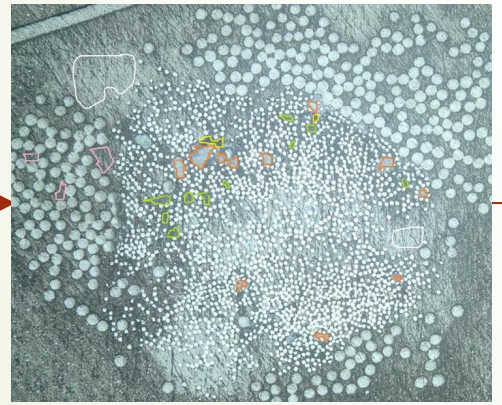


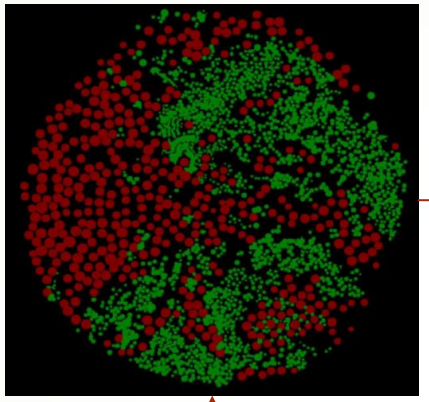


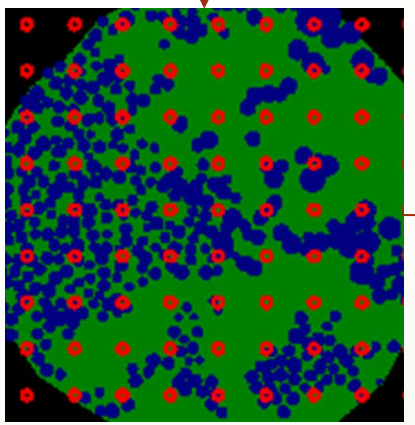
AI/ML Techniques Possibilities

- **Continuous collection** of manufacturing data - **numeric, alphanumeric 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



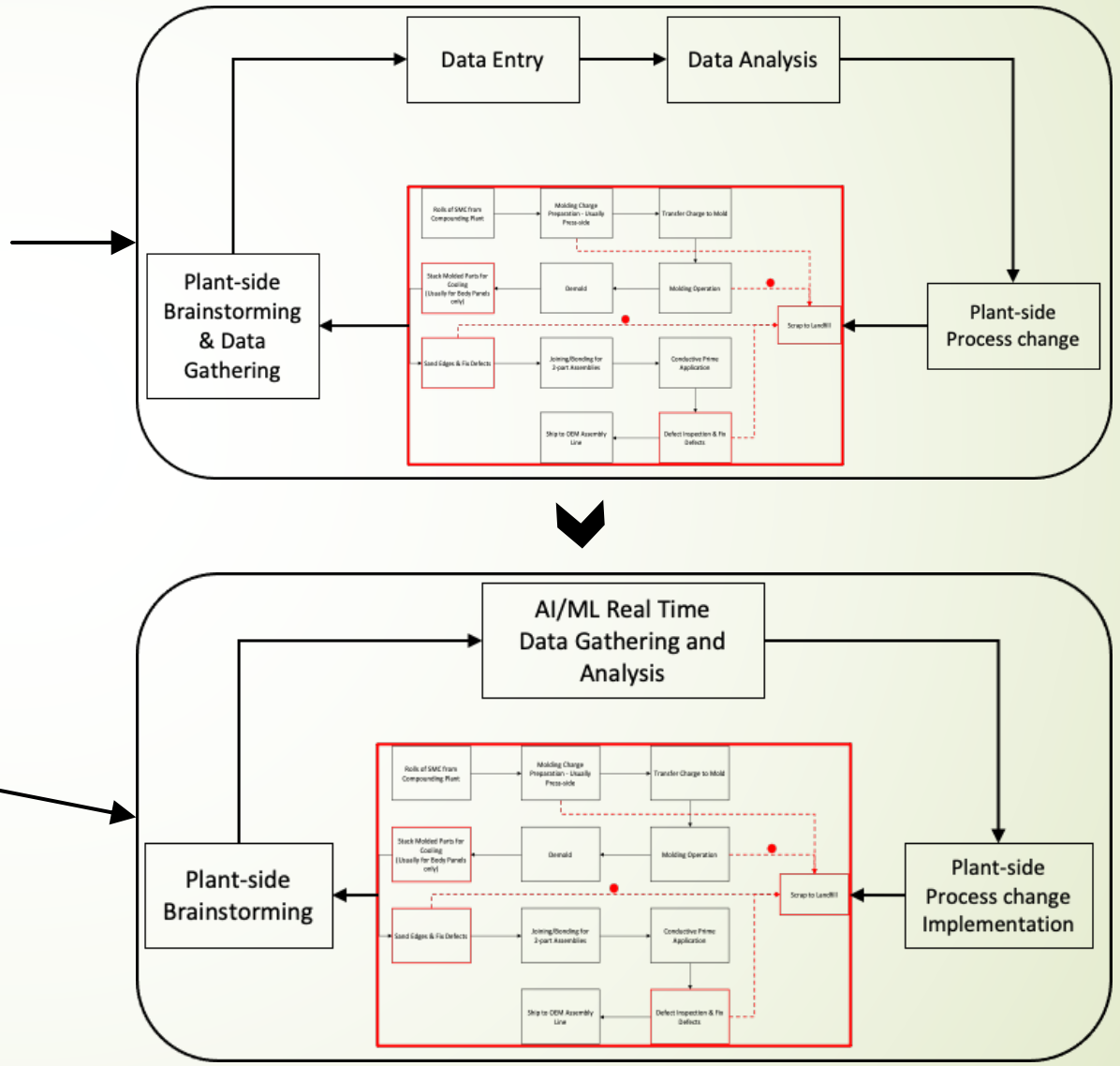




- An **example to demonstrate AI-ML** in composites
- Use ML to learn the images of the key ingredients in a cross section
  - Fibers; Fillers; Resin; Porosity; etc.
- Develop an Algorithm & quantify each individual image
- The entire **ML & Algorithm development took 7 days to develop**

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!