# Optimization of Mold-in-Color Composites for Geometrically-Complex Structural Applications

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INEOS Composites

# About INEOS Composites

- Formerly Ashland Composites. Was purchased by INEOS in late 2019
- Our transportation brands, like Arotran™ and Derakane™, are used for a long list of automotive and heavy truck BMC and SMC applications
- Worldwide production capabilities with an extensive R&D facility located in Dublin, Ohio



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# Session Outline

- Research Goal:
  - Cut down new material adoption time by Tier 1 manufacturers while increasing R&D success rates for mold in color composites

- Research Overview
  - Studying press side parameters in SMC formulations
  - Comparing different resin systems at the same press parameters
  - Optimization of high performing SMC formulations

# What are Mold-in Color Composites?

- Mold-in color means that the color is molded into the part and it doesn't require a secondary painting step
- Typically exterior parts made from SMC
- Requires good part appearance
- First introduced on the Honda Ridgeline stowage tub and trunk box with an Arotran 805 resin SMC formulation

# Accurate Testing of Mold-in Color

- Mold-in color composites present unique manufacturing difficulties that are not easily reproduced on flat-panel parts
  - Flat panel appearance doesn’t match full-sized part appearance
- To account for this INEOS has purchased a tool specifically designed for the study of geometrically-complex parts
  - Adapted from the Honda Ridgeline
  - Deep vertical draw
  - Heavy grained texture

# Experiment One – Press Side Optimization

- Optimizing an Arotran 805 based mold-in color formulation for appearance
  - This kind of study could previously only be accomplished by breaking into production
- Complex DOE design looking at press-side parameters

| Factor | Levels |
|---|---|
| **Cure Temperature (˚C)** | 135, 146, 157 |
| **Press Pressure (PSI)** | 170, 260, 350 |
| **Charge Weight of SMC (g)** | 2500, 2800, 3100 |
| **Layup Time (s)** | 30, 60, 90 |
| **Charge Layup** | Five Different |

# Experiment One – Charge Layups





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# Appearance Rating System


Poor appearance, score of 12


Poor appearance, score of 4



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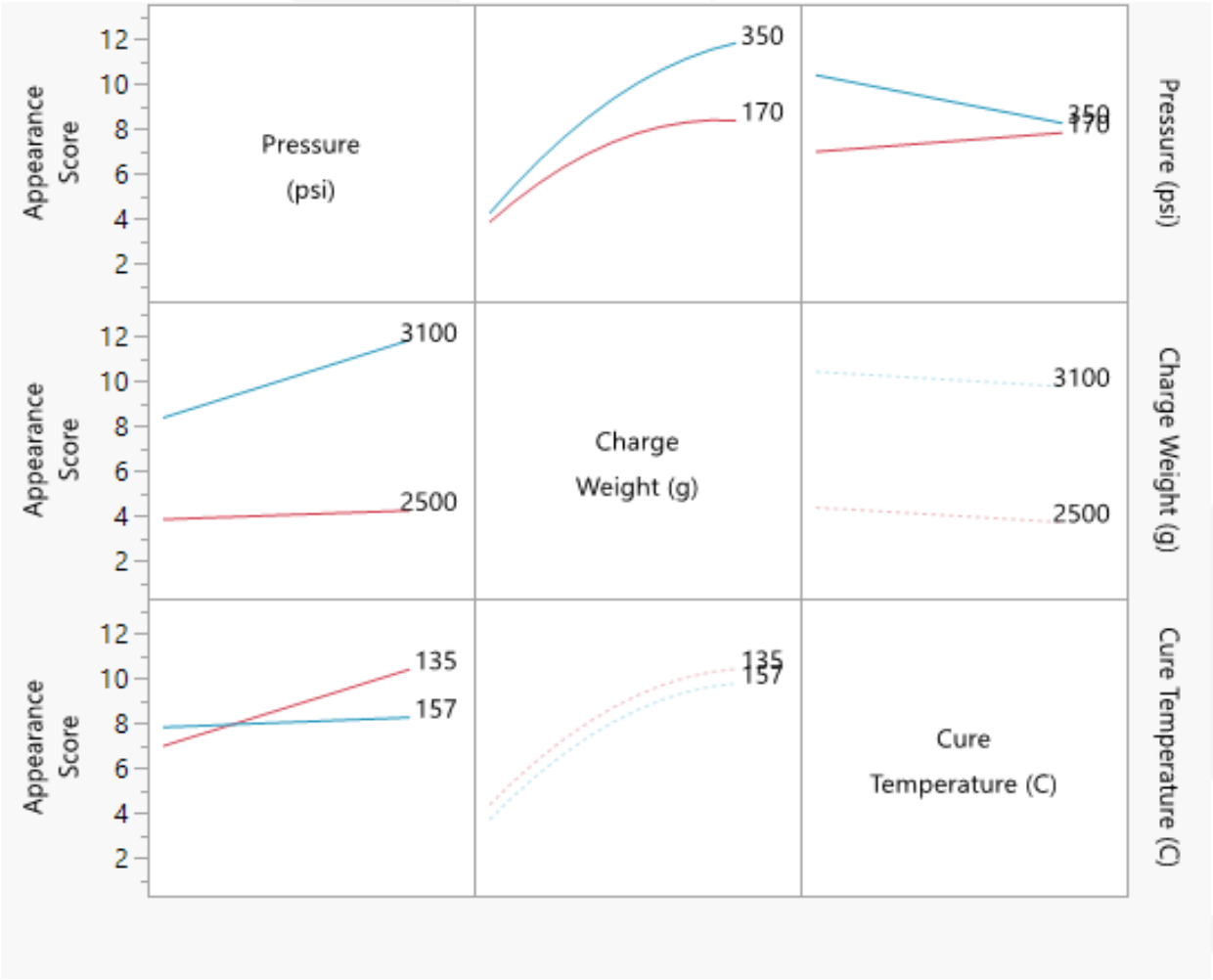
# Experiment One Findings

- Parts were rated on a scale of 3-12 – lower being better
- It was found that to optimize appearance, lowering the cavity pressure had the most significant effect
- Charge pattern and layup time had no statistical effect on appearance



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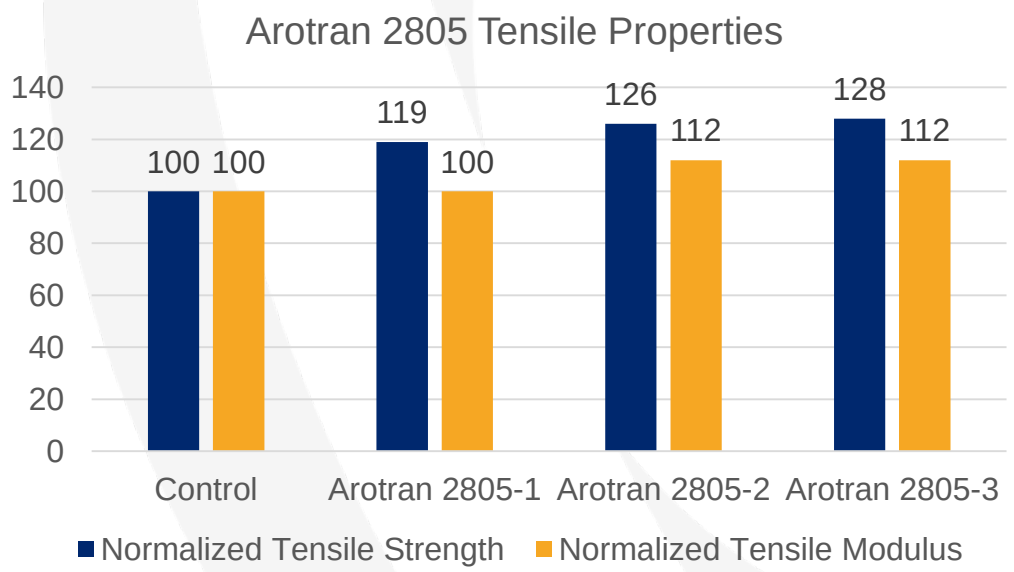
# Arotran 2805

- Arotran 2805 is a next-generation composite resin designed for mold-in color applications
- It has superior mechanical, processing, and accelerated weathering properties when compared to the previous generation resin
- However, prior to the acquisition of the tool, the color and appearance that it provides in a molded part was not able to be evaluated




| Base Resin | SMC Panel Testing | | |
|---|---|---|---|
| | Part Specific Gravity | Fiber Glass (Volume %) | Engineered Filler (Volume %) |
| Control | 1.75 | 37.5 | 0 |
| Arotran 2805-1 | 1.64 | 41.4 | 12.3 |
| Arotran 2805-2 | 1.67 | 43.3 | 11.9 |
| Arotran 2805-3 | 1.7 | 45.1 | 11.5 |



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# Experiment 2 – Resin Comparisons

- Due to production constraints, parts made of Arotran 2805 and Arotran 805 were made using the same molding conditions
- The press parameters were chosen to give poor appearance
  - 3100 g charge weight, 350 PSI, and 300 ˚F molding temperature
- It was found that the Arotran 2805 formulation outperformed the Arotran 805 formulation

| Formulation | Average Appearance Score |
|---|---|
| **Arotran 805 Based** | 11 |
| **Arotran 2805 Based** | 6 |



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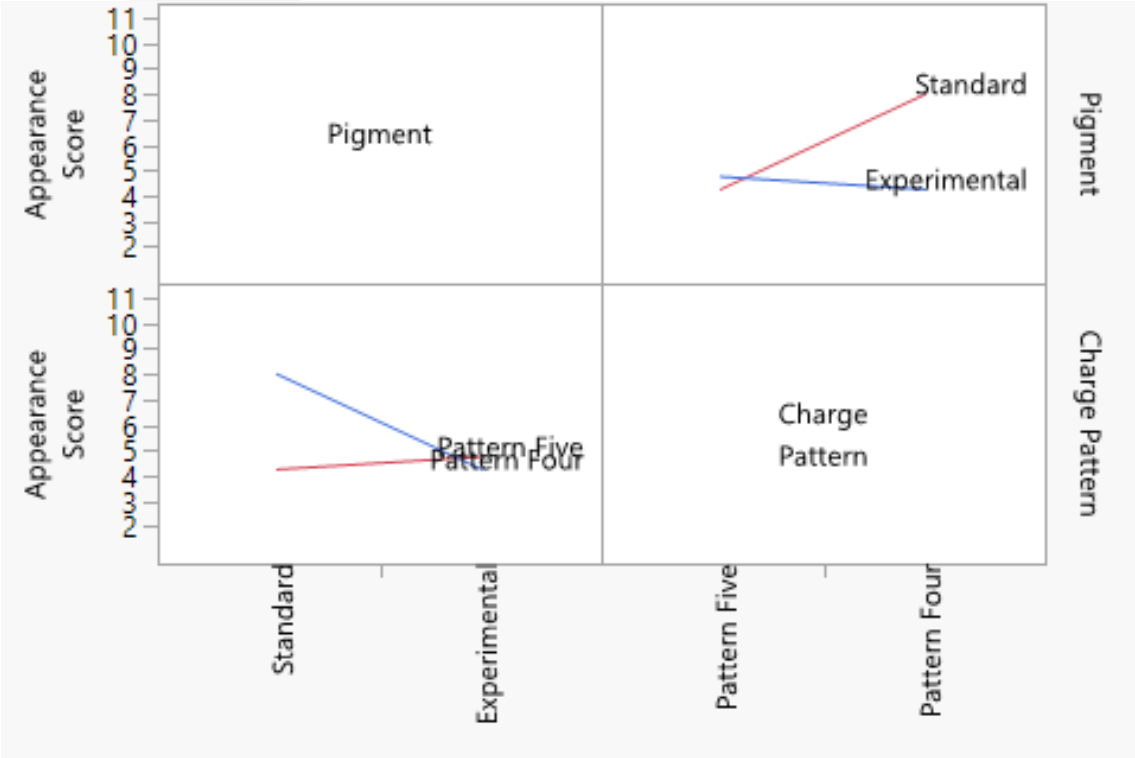
# Experiment Three – Arotran 2805 Optimization

- Replicating Experiment One with the purpose of determining if similar results are obtained using Arotran 2805 as the resin
- One added factor – pigment selection
  - Including an experimental INEOS pigment

| Factor | Levels |
|---|---|
| **Cure Temperature (˚C)** | 146 |
| **Press Pressure (PSI)** | 170, 260, 350 |
| **Cure Length (min)** | 2.0 |
| **Charge Weight of SMC (g)** | 2200, 2500, 2800 |
| **Charge Pattern** | Two Different |
| **Pigment Selection** | Standard or Experimental |

# Experiment 3 Findings

- Arotran 2805 was found to be less effected by molding conditions other than charge pattern
  - The opposite was observed with Arotran 805
- Appearance being less dependent on mold parameters allows for a more “robust” system
  - Production can be ran at a wider variety of parameters
- Pigment selection was also a driver of appearance



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# Conclusions

- Optimization of mold-in color SMC requires extensive testing
  - Non-flat panel testing is necessary to achieve this and the level of thoroughness required will be difficult to accomplish on a production line
- Part appearance can be driven by both resin and molding optimization and is dependent on the individual formulation
  - Not discussed in this presentation, but all these changes affect properties like part-fill and need to be tested in tandem
- Arotran 2805 is a robust resin system that allows for high quality parts at a wide range of molding parameters

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