Process Modelling in Rotomolding – Practical Benefits and More

NOVA Chemicals

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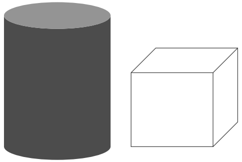
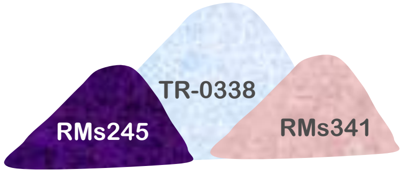
I Want To Rotomold a New Product But…

1 I need to design and make a mold…



What if we found an easier way?

2 I need to find the right material/resin …



3 I need to find the right process conditions…

Parameter	Set Point
Oven Temp	?
Cook Time	?
Rotation Speed	?

✖ TIME

✖ MONEY

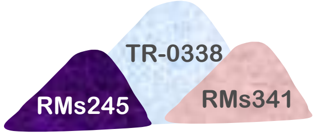
✖ RESOURCES

The solution – Simulation

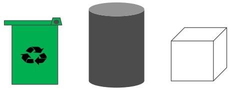
** Realize benefits by changing these inputs

1 - Define Inputs

Material and Powder Properties



Mold Design/Materials



Process Conditions

Parameter	Set Point
Oven Temp	?
Cook Time	?
Rotation Speed	?

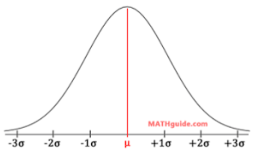
Necessary to Establish Confidence in Simulation and Outputs

2 – Run Designed Simulation

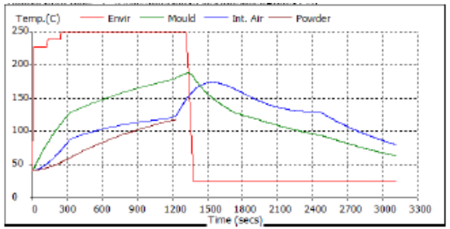
RotoSim™

3 – Use Outputs to Guide Operations

Thickness Distributions



PIAT Curves/Degree of Cure

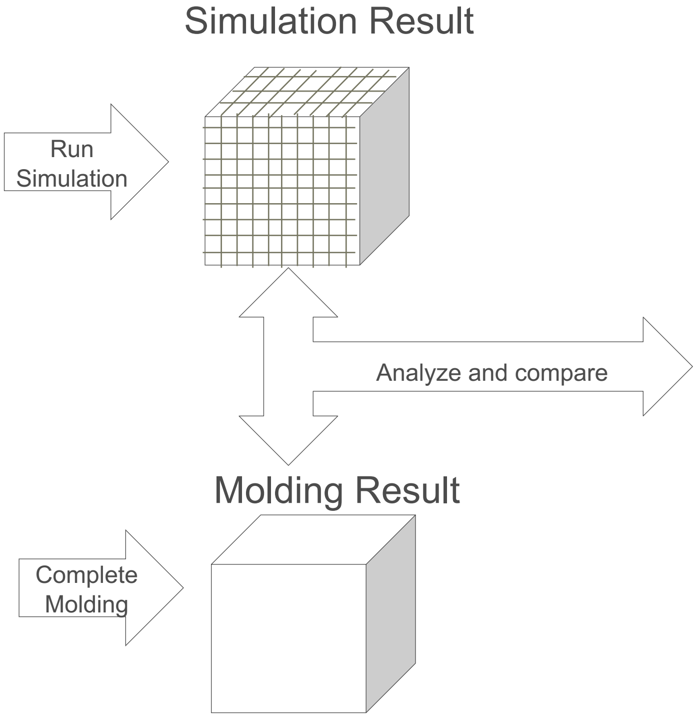


How Do We Establish Confidence in our Simulation?

VALIDATION:

Simulation Input:

- Resin = thermal properties, powder size, etc.
- Mold = Size, material, etc.
- Oven temp = Variable
- Oven time = Variable



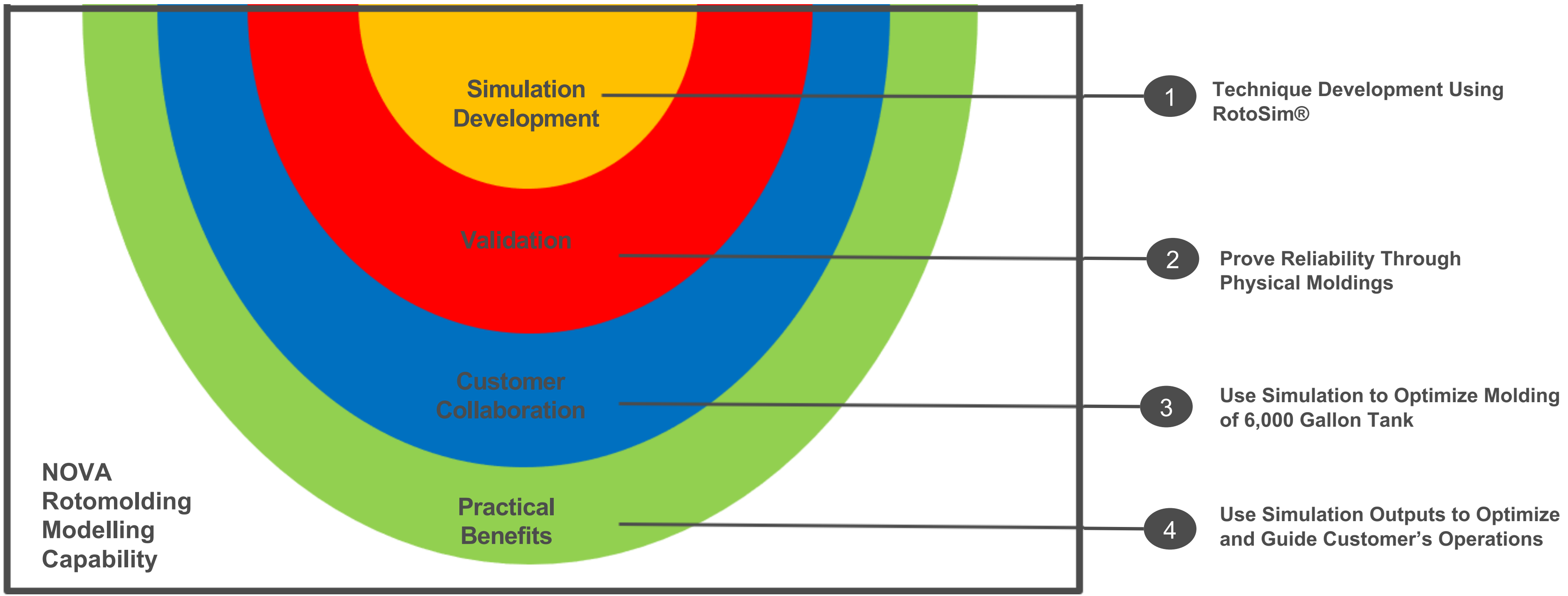
Property	Simulation	Real life
As-molded Density	0.9462	0.9459
Thickness Variation	0.015”	0.012”
Degree of Cure	1233	1400
PIAT	380 F	410 F

Experimental molding trial

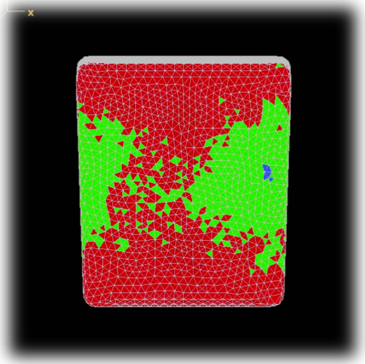
- Resin =RMs245
- Mold = Standard Test Cube
- Oven temp = 520 F
- Oven time = 18 minutes

What Objectives did we set out for?

SIMULATION SERVICE MODEL FOR NOVA CUSTOMERS



Step One: Set up Simulation with RotoSim®

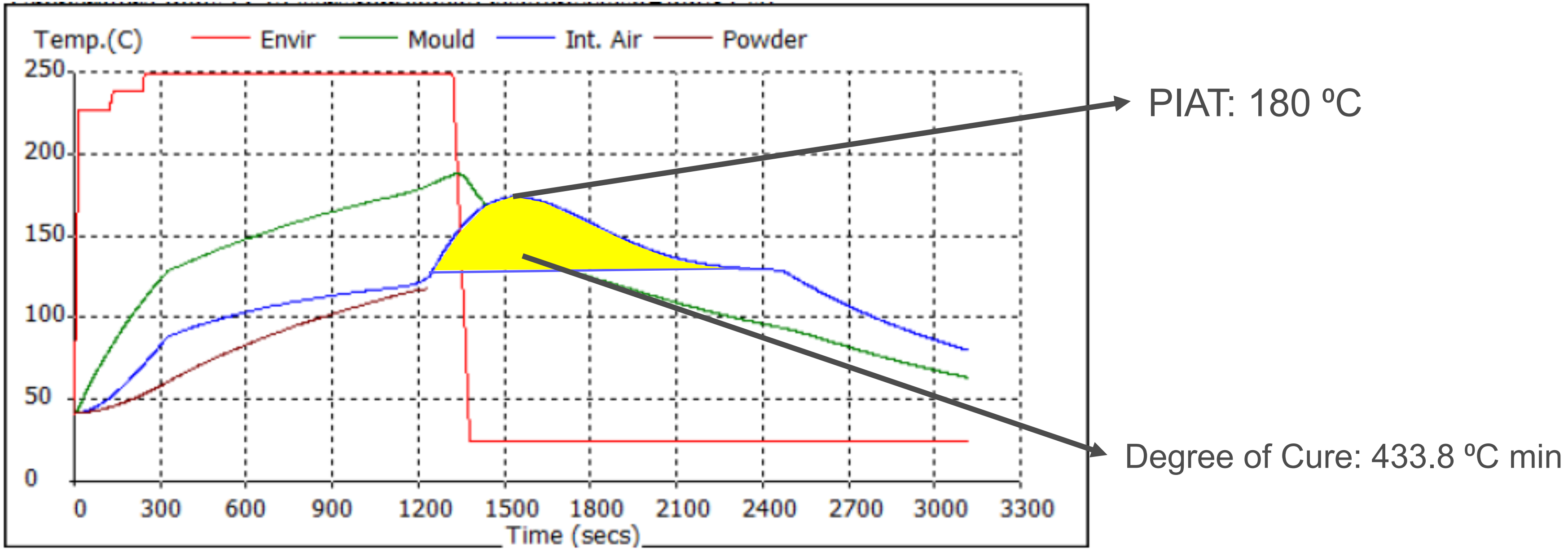


1. **Material Data:**
   - SURPASS® RMs245
   - Density = 0.945 g/cc
   - Melting point = 267 ºF
   - Etc.

2. **Mold/Part (SolidWorks)**
   - 18” standard test cube mold
   - Cast aluminum
   - Part thickness = 0.125 “

3. **Process conditions**
   - Oven temperatures: 480 F, 520 F, 560 F, 600 F
   - Cook Times: 20 to 32 minutes
   - Arm Speed: 4 to 8 rpm

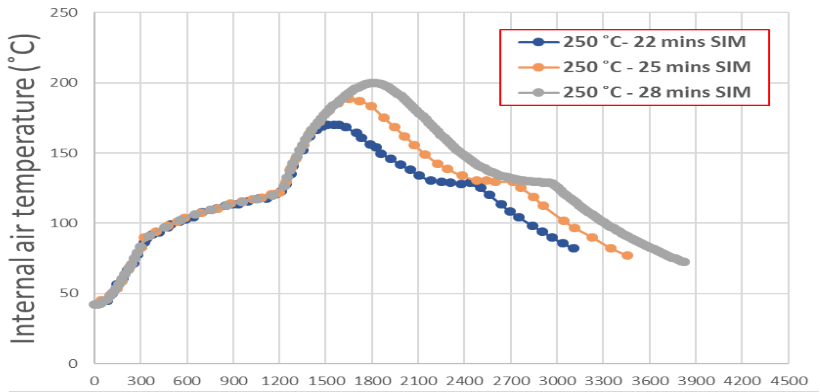
Outputs – PIAT and Degree of Cure

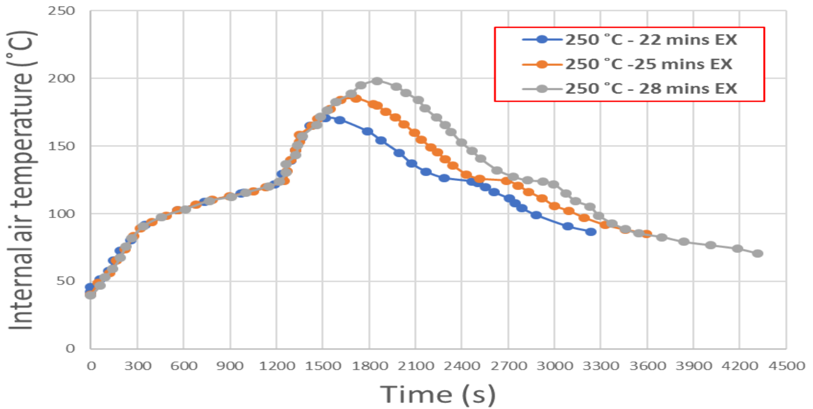


Use Degree of Cure and PIAT values as predictors of performance

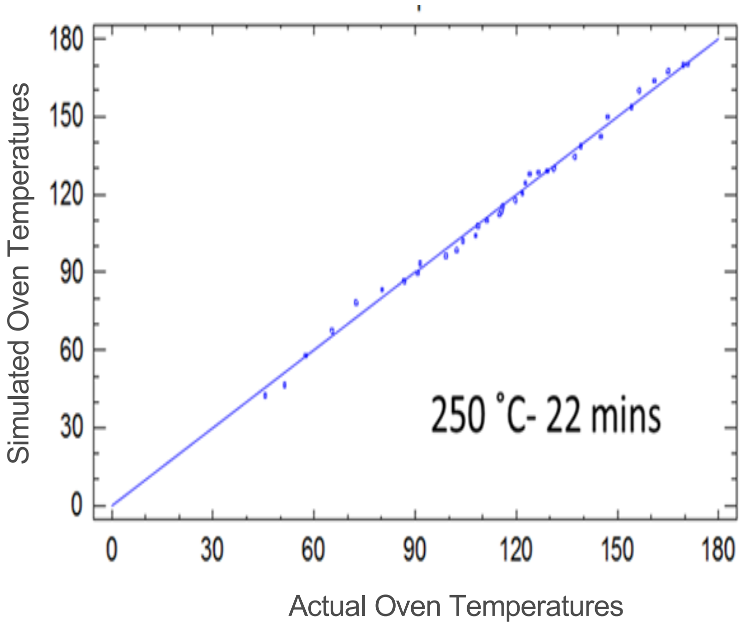
Step 2: Validation with experimental results

Simulated & Experimental PIAT Curves at 250 ºC at different oven times





Predicted vs. observed oven temperatures



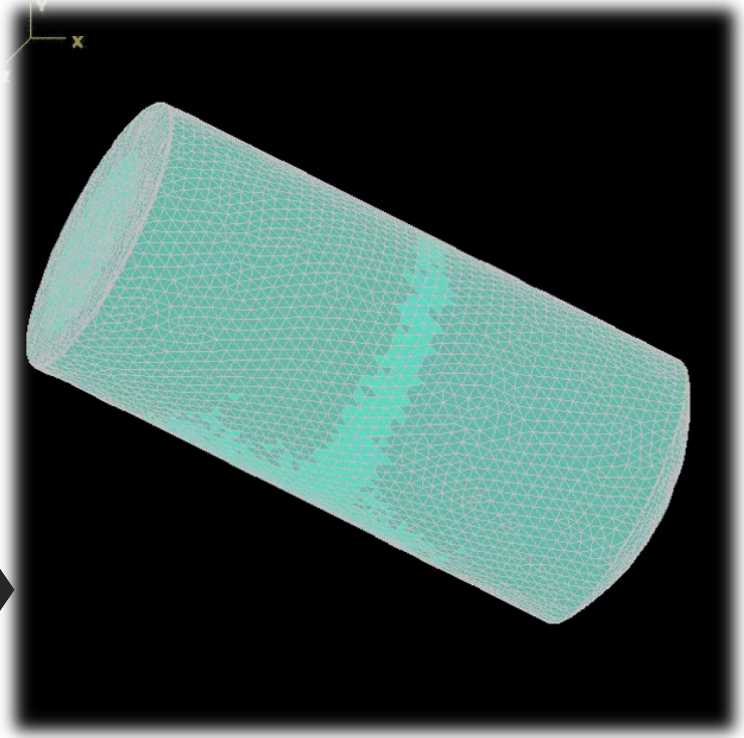
Step 3: Scale up to 6,000 Gallon Tank (Customer Collaboration)

We helped our customer explore:

- ✓ **New mold**
- ✓ **New material/resin**
- ✓ **Optimal conditions**

18” Test Cube

SCALE UP



6,000 Gallon Tank

Inputs

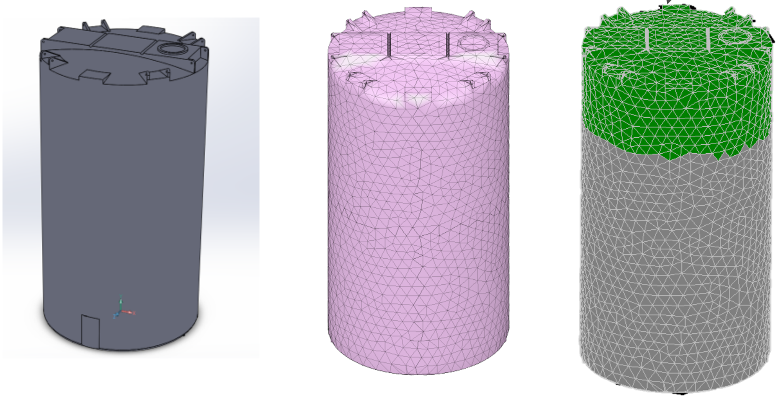
34 Simulations saved:

✓ ~130,000 lbs resin
✓ 272 hours machine time

Conditions	Levels		
Arm speed (RPM)	Low	High	
Temperature (ºC)	Low	Medium	High
Cook Time (min)	Low	Medium	High
Resin	RMs245	Low MI HDPE	
Shot weight (lbs)	Low	High	

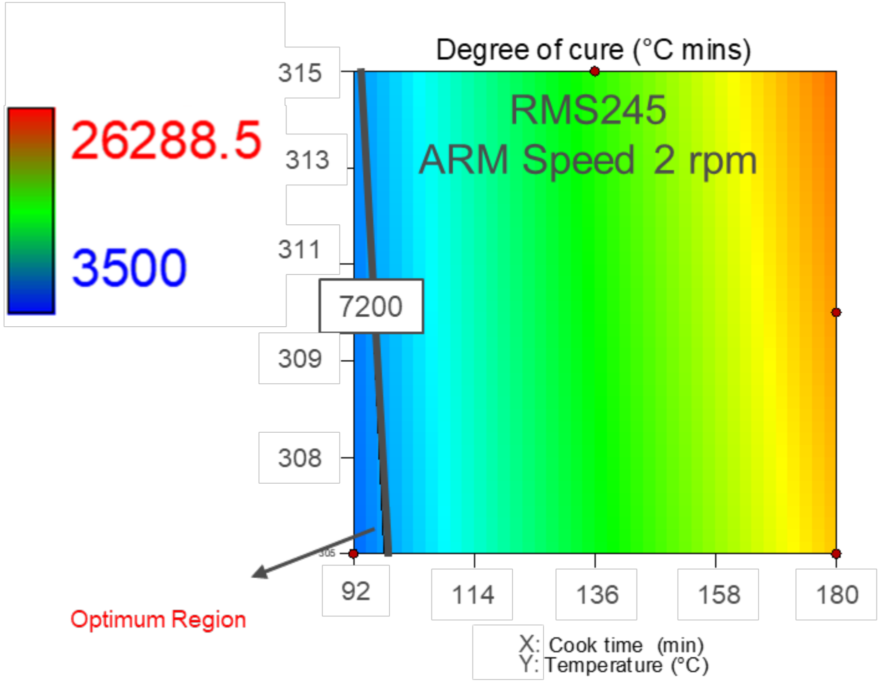
OUTPUTS:

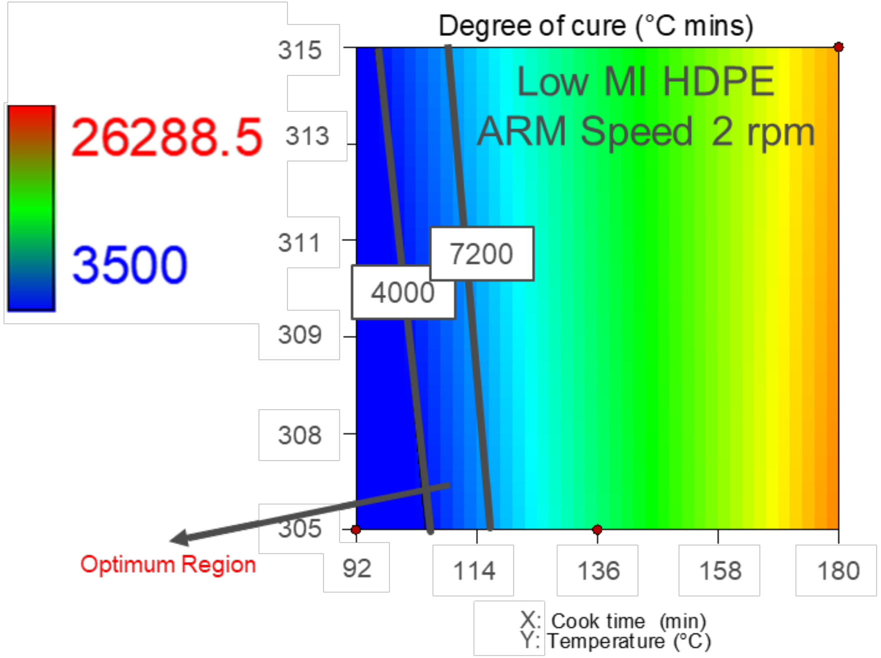
1. **Degree of Cure (from PIAT)**
2. **Thickness Distribution**



Outputs

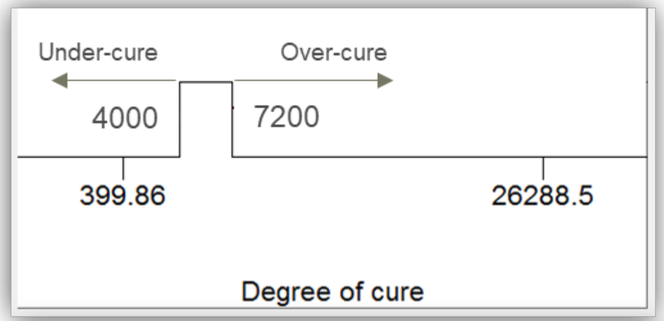
OBJECTIVE: D.o.C Range must be between 4000-7200



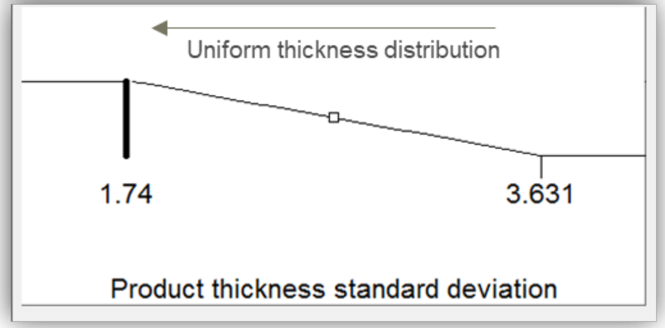


Find Processing Conditions Such That:

1) Degree of cure is between 4000 to 7200

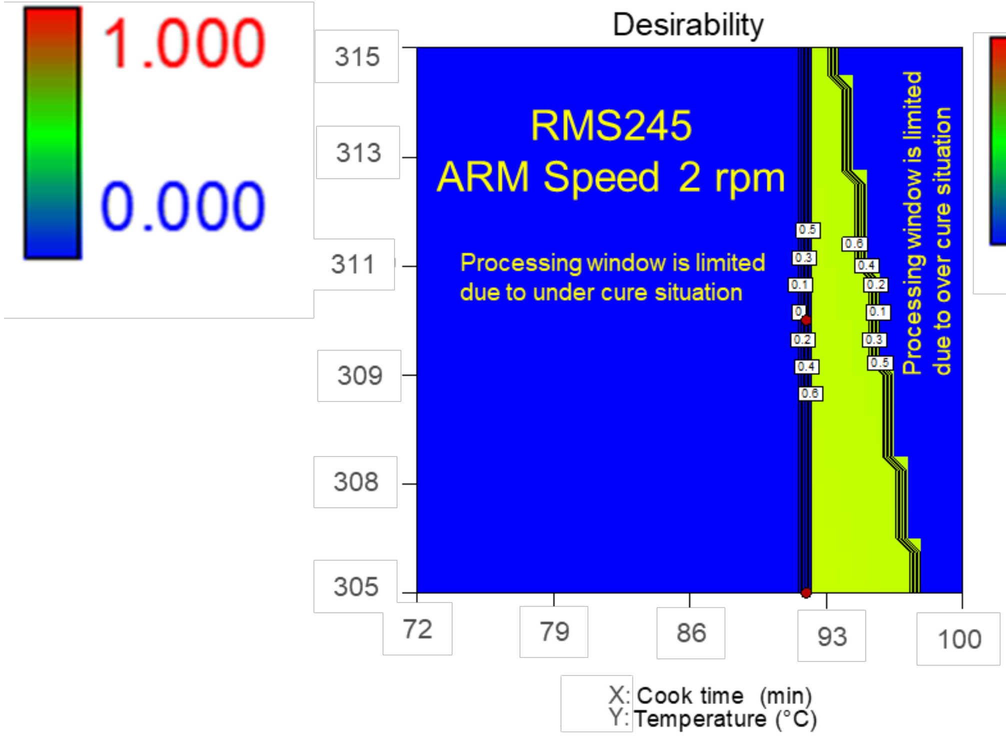


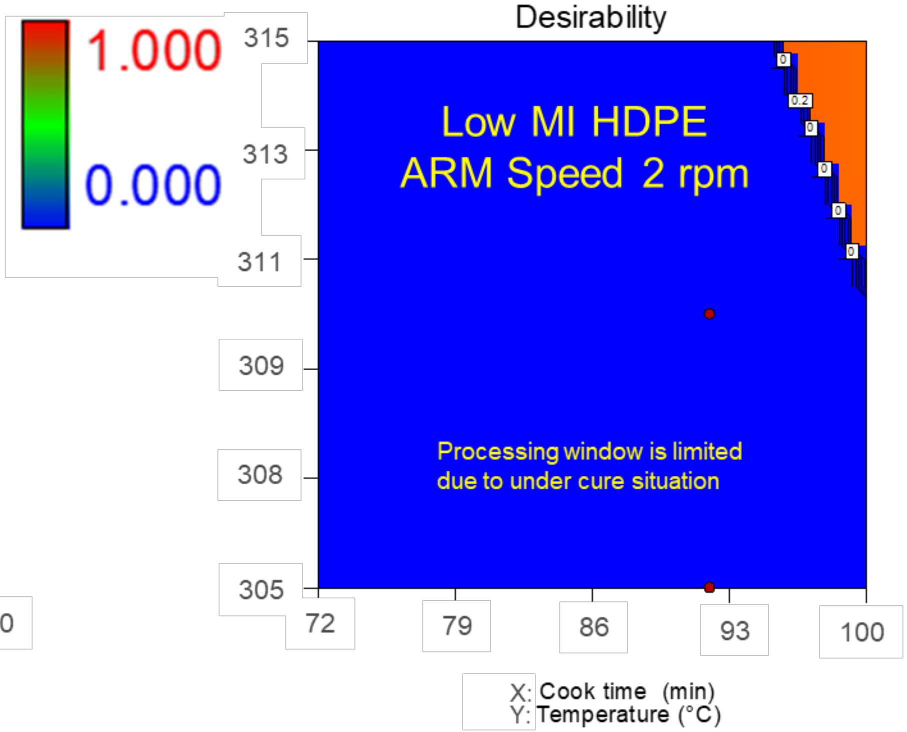
2) Minimize thickness variation



**Possible to optimize other outputs (eg: cycle time) **

RESULTS: Optimization & processing window (lower window)

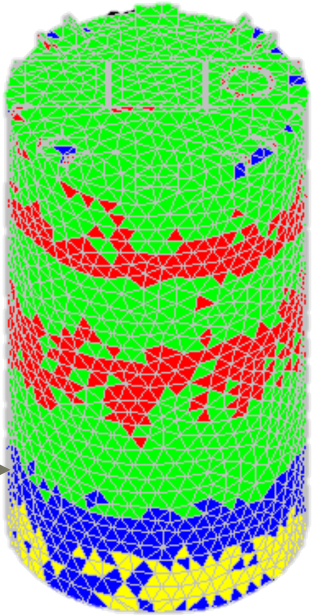




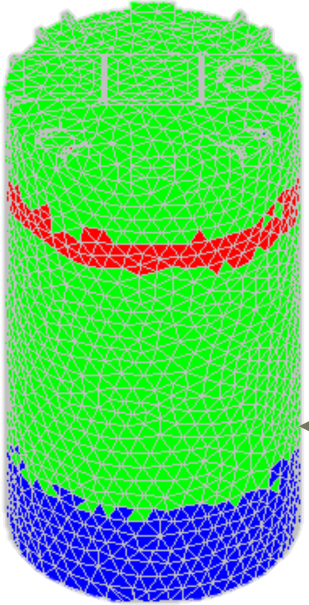
RESULTS: Thickness Distribution

Note: Increasing ARM Speed drastically improved thickness Variation

Measured Experimental Thickness = 24.696 mm



Thickness range				Colour
	Thickness	<=	20 mm	Red
20 mm	< Thickness	<=	24.46 mm	Green
24.46 mm	< Thickness	<=	28 mm	Blue
	Thickness	>	28 mm	Yellow



Measured Experimental Thickness = 22.352 mm

RMs245 (1.7 MI)
ARM Speed 2 rpm, 92 min, 305 ˚C (580 ˚F)

Low MI HDPE
ARM Speed 2 rpm, 92 min, 305 ˚C (580 ˚F)

Closing Comments and Future Outlook

Benefits of Simulation Realized:

- Bypassed molding trials through 34 simulations which saved:
  - ~130,000 lbs resin
  - 272 hours of machine time
- Found optimal conditions to make parts with perfect cure and uniform thickness distribution

Simulation is the future and NOVA is here to embrace it

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