AUTODESK

Moldflow Summit 2025: Applying Windage at General Motors

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Moldflow Expert Certified

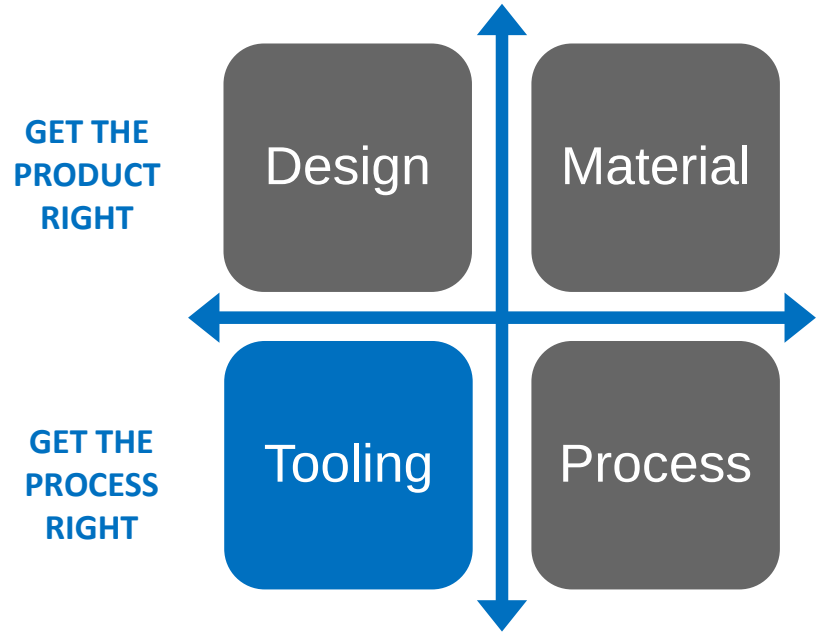
GENERAL MOTORS

GM Windage Values

Molded Part Dimension

Over 800 Injection Molded Plastic Parts in a Vehicle

Each with Specific Geometry Requirement



What Is Windage?

“Windage” is slang describes tool adjustments to offset difficult to predict shrinkage.

Comes from “Kentucky windage”, slang describing how a rifle shooter adjusts their aim to account for wind, gravity, and/or motion of the target

What does this mean for injection molded part?

Windage is the process of in-mold geometric compensation for part warpage needed to produce a part matching the desired shape

When is windage applied?

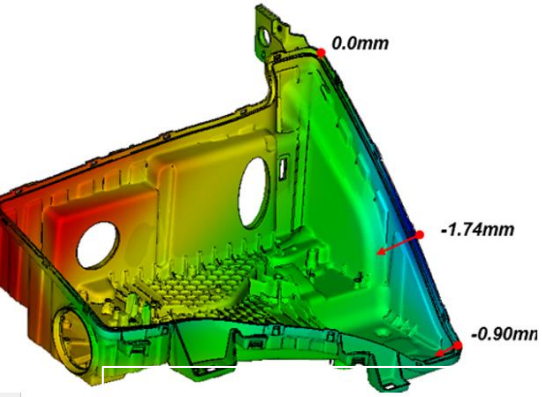
Before mold construction – **GM TARGET**
After mold construction

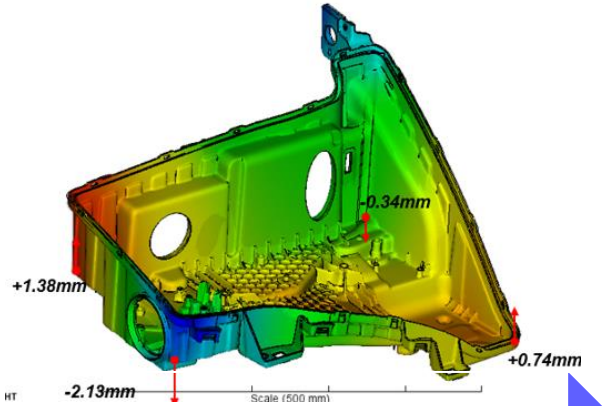
GM Believes In Using Windage

1. Achieve dimensionally acceptable parts earlier in the program
2. Fewer tool tryouts and DOEs
3. Less tuning time
4. Open molding window
5. Better product quality
6. Simplified assembly issues
7. Improving overall workflow
8. Lower engineer time (soft cost)
9. Potentially faster and less costly PPAP

No Windage – Example 1

Part:	**Exterior Lamp**
Result:	**Numerous DOEs, Material Changed**





Moldflow Analysis → Optimized Molding Process → Assembly → **Fail**

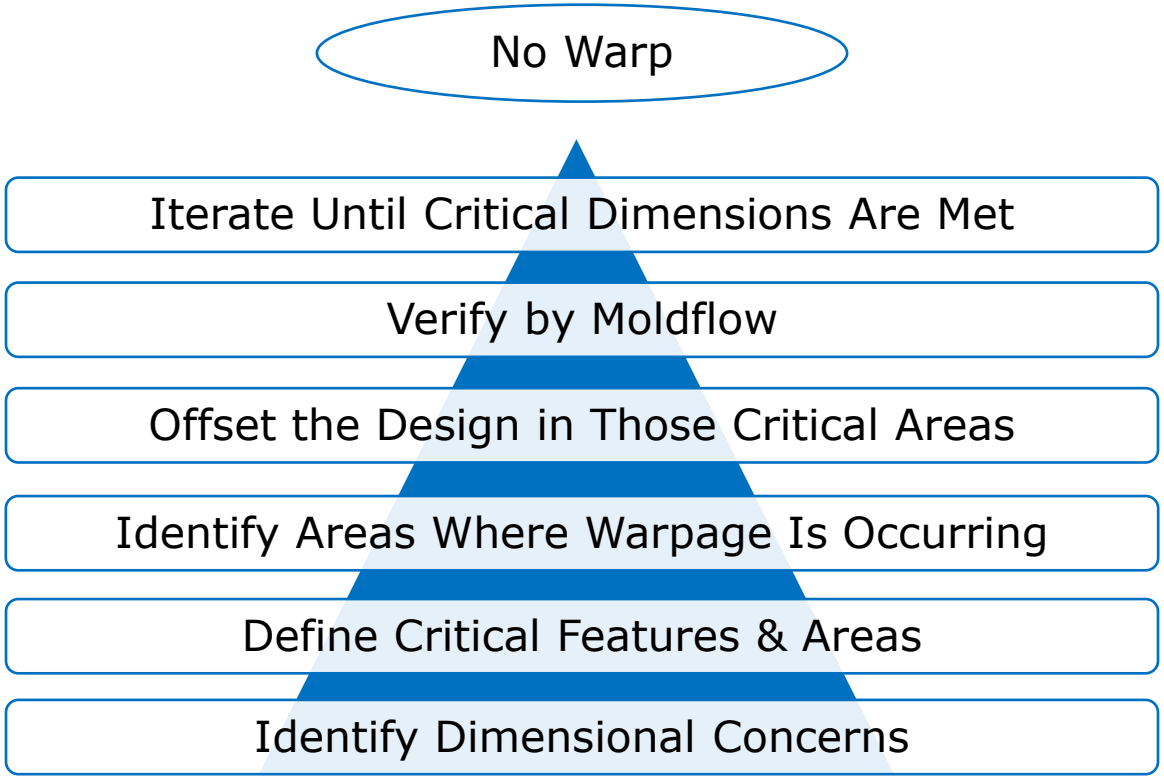
No Windage – Example 2

Part:	**Exterior Trim**
Result:	**Cooling fixture, Numerous DOEs, New Tool with Windage Both Ends**

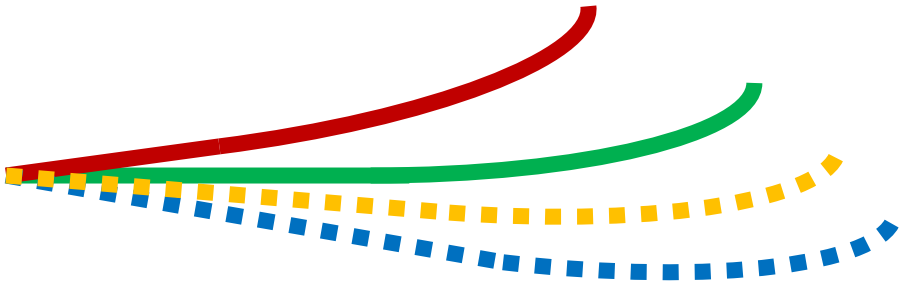
Moldflow Analysis → Optimized Molding Process → Cooling Fixture → Chrome Plating → **Fail**

Windage Process

Windage Methods



Windage Methods Concept Chart



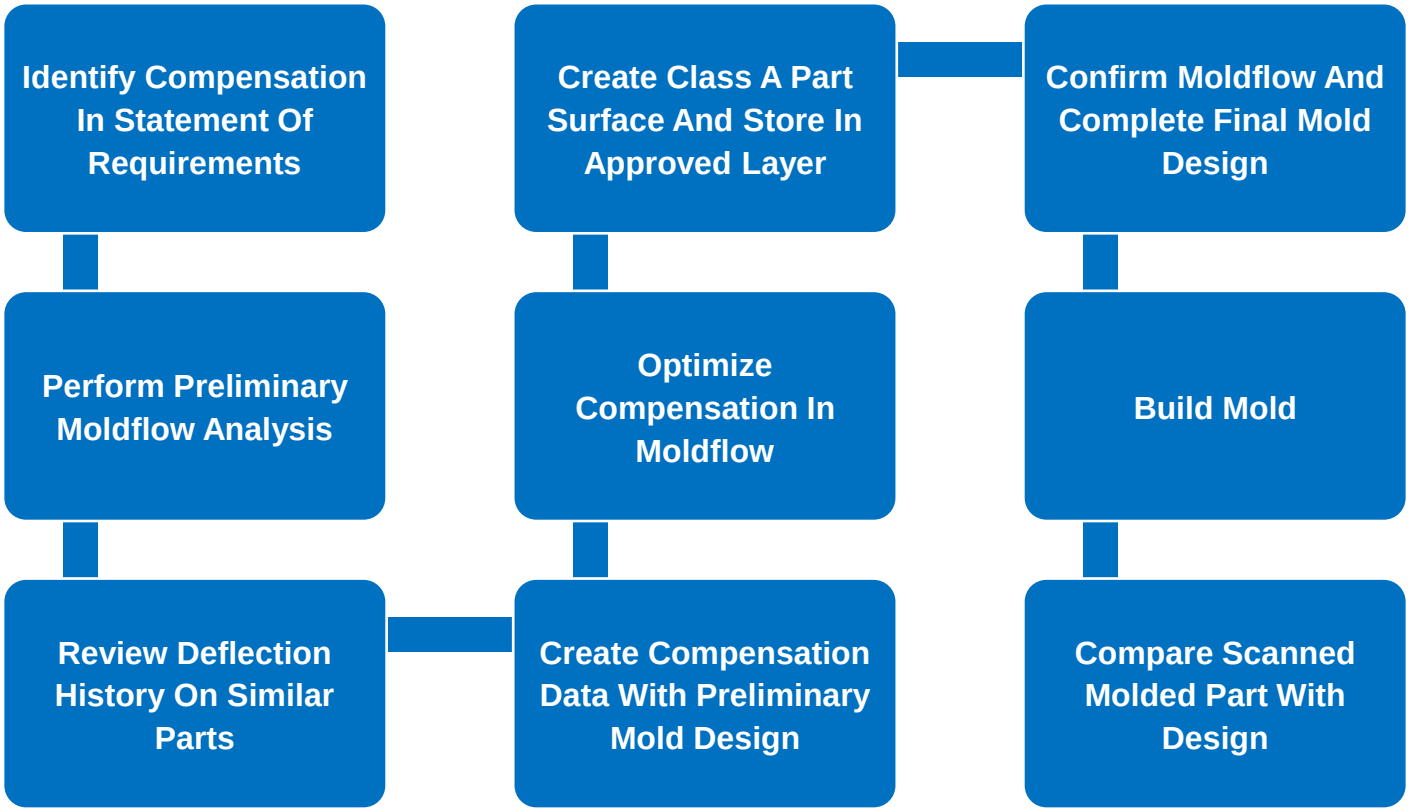
Original Design Warped Part Result

Original Design //Windage Part Result

Original Design Expanded

Windage Design Expanded

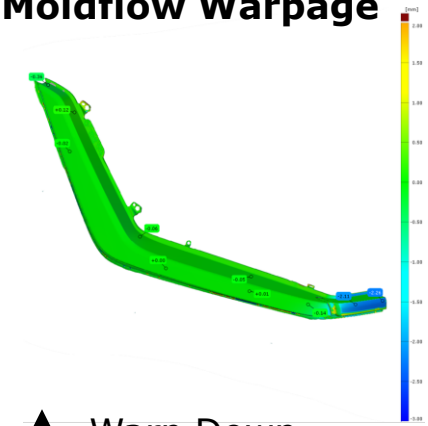
Windage Process (New Standard In Development)



Windage – Example 1

Part:	**Exterior Rear Lighting Optic Part**
Result:	**Added Windage to Achieve Near Net Design Dimensions**

Moldflow Warpage



Warp Down (2.3mm)

Add Windage

Windage vs Part Design

Windage Moldflow vs Part Design

Windage Up (2.8 mm)

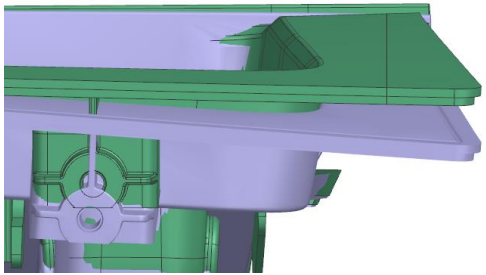
Final Warpage

Final Results Near Net

Windage – Example 2

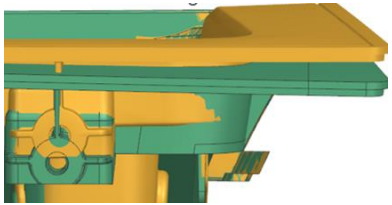
Part:	**Exterior Battery Charge Port Door**
Result:	**Added Windage to Achieve Near Net Assembly Dimensions**

Moldflow Warpage

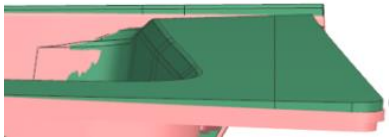


Warp Down
(7mm)

Add Windage



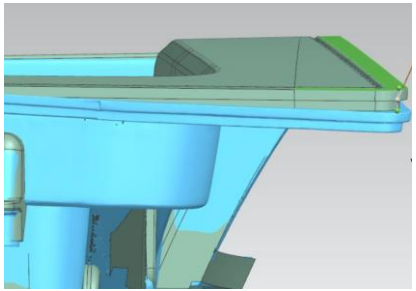
Windage
(6mm Up)



Moldflow
Warpage
(1mm Down)

Windage Up
(6mm)

Final Warpage

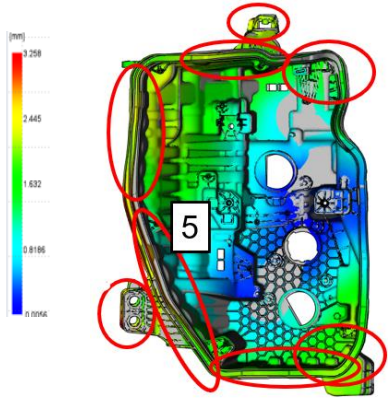


Physical Part
(2.7mm Down)

Windage – Example 3

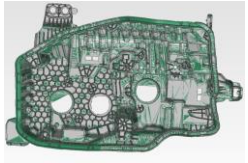
Part:	**Exterior Rear Lighting Housing**
Result:	**Added Windage to Achieve Near Net Design Dimensions**

Moldflow Warpage

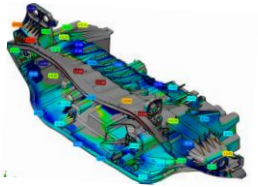


Warp Different Direction (up to 3mm)

Add Windage



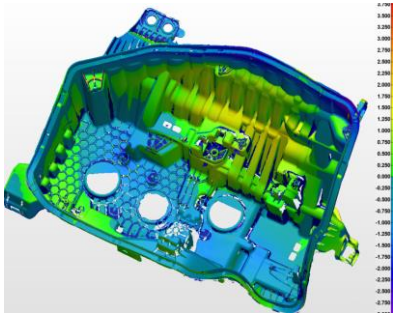
Windage vs Part Design



Windage Moldflow vs Part Design

Windage 8 locations (up to 2.5)

Final Warpage

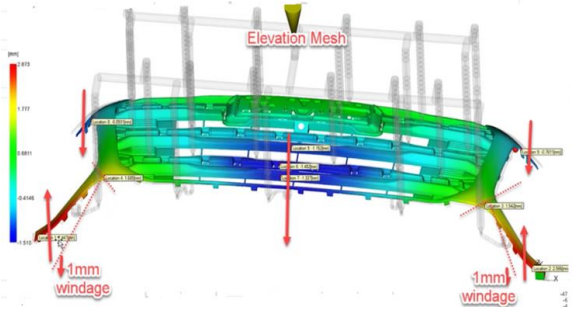


Final Results Near Net

Windage – Example 4

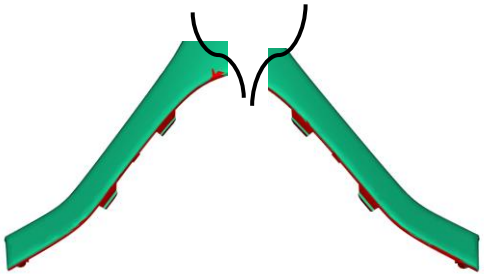
Part:	**Exterior Grille**
Result:	**Added Windage to Achieve Open Molding Window/ Near Net Assembly**

Moldflow Warpage



Warp Up (2.5mm)

Add Windage



Windage down (1mm)

Final Warpage

Final Results Near Net

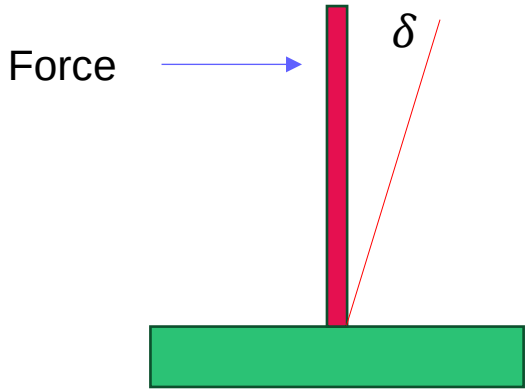
Additional Windage Considerations

Buckling Part

Criteria **Eigenvalue > 1.5, Good for Windage**

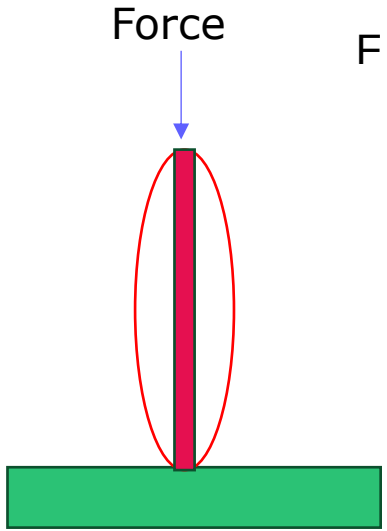
Eigenvalue < 1.5, Caution or Avoid Windage

$$\delta = \frac{F L^2}{3 E I}$$



Stable Predictable Small deflection

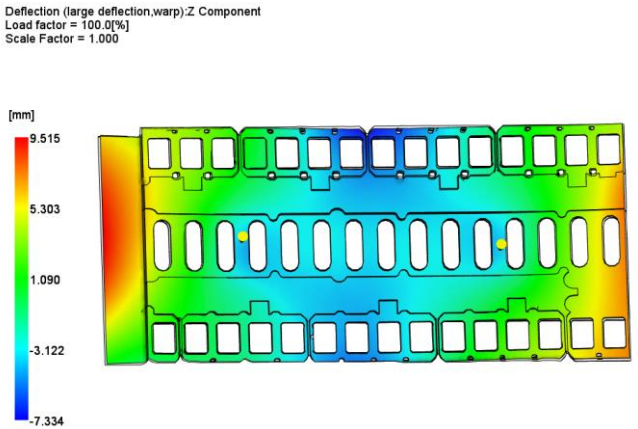
$$F = \frac{\pi^2 E I}{(K L)^2}$$



Buckling Unstable Large deflection

Large Deflection Example

Part	**30% Glass Filled PP**	**Eigenvalue <1.5**
Result	**Large Deflection**	



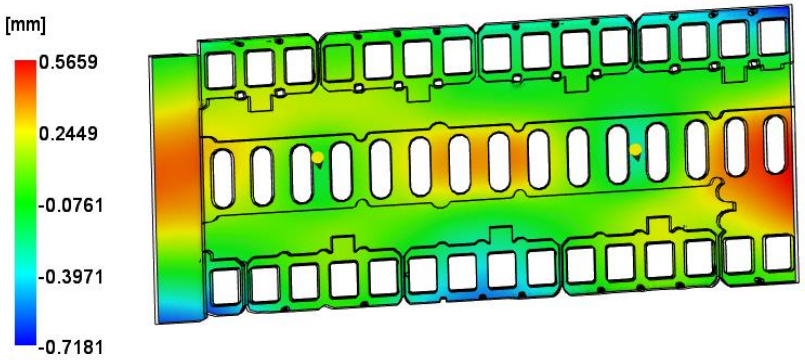

```
Lowest  2 eigenvalue(s) and corresponding eigenvector(s):
Eigenvalue lambda    1 =        -0.35824585
Eigenvalue lambda    2 =         0.38754508

Switching from buckling check to large deflection warpage.
```

Large Deflection Change To Small Deflection

Part	**40% Talc Filled PP Eigenvalue >1.5**
Result	**Small Deflection**

Deflection, all effects:Z Component
Scale Factor = 1.000



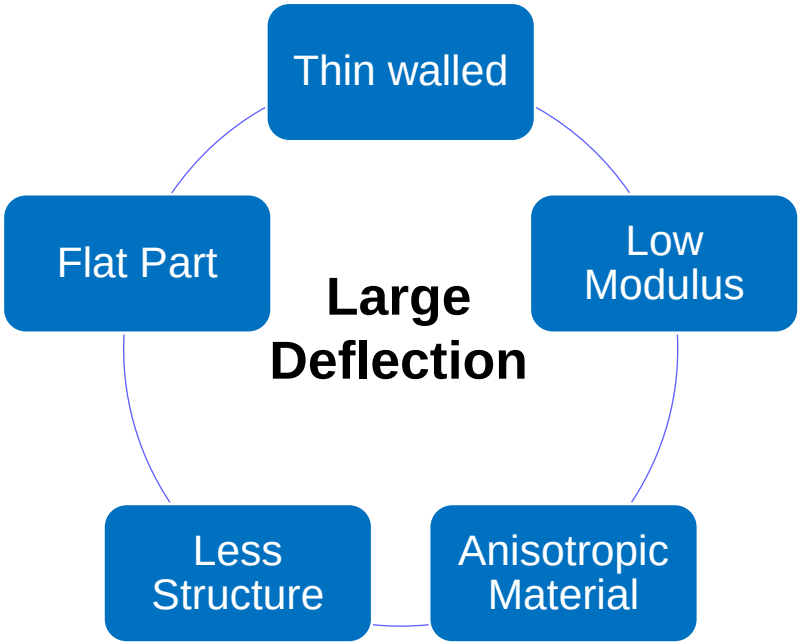

```
Lowest  2 eigenvalue(s) and corresponding eigenvector(s)
Eigenvalue lambda    1 =        -1.92855394
Eigenvalue lambda    2 =         2.10771251
```

Incorrect Mindset for Large Deflection

1. A Small Part Won’t Experience Large Deflection.
2. High Shrinkage material causes Large Deflection
3. High Young’s Modulus Materials Don’t Show Large Deflection.
4. Large Deflection Is Rare.
5. It Can Be Ignored.

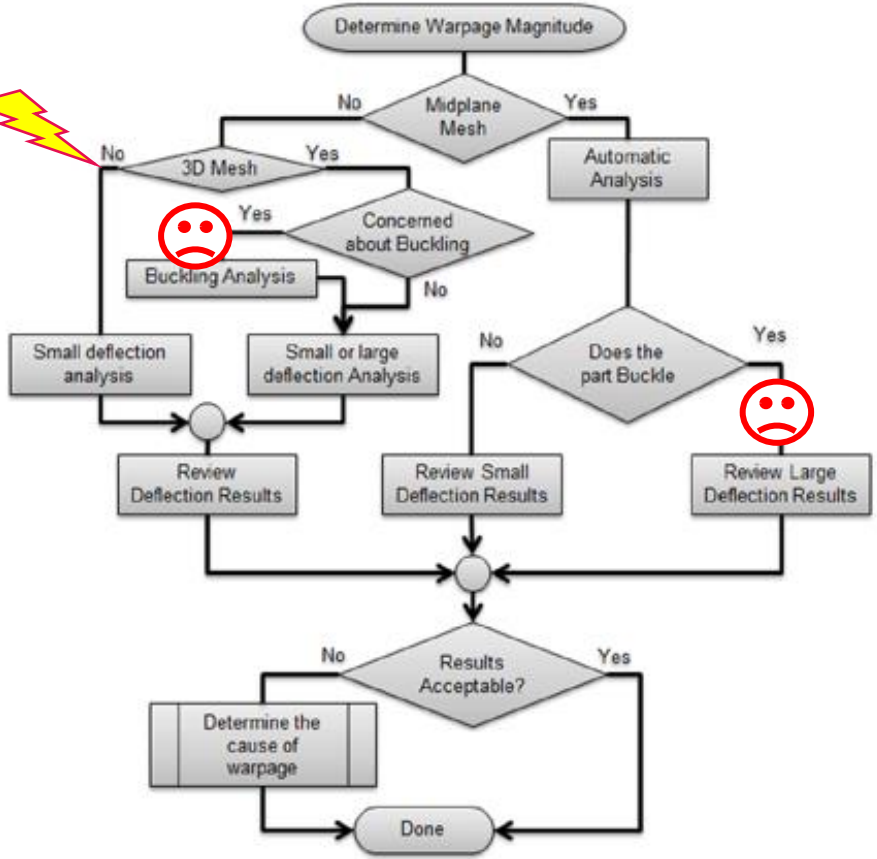
Large Deflection Assumption

Criteria	Large Deflection Characteristics



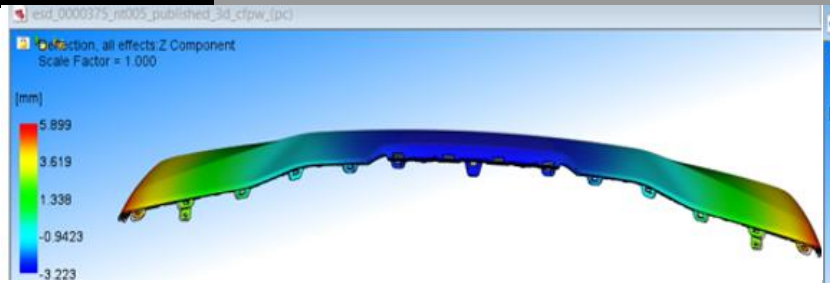
Buckling/Large Deflection Analysis

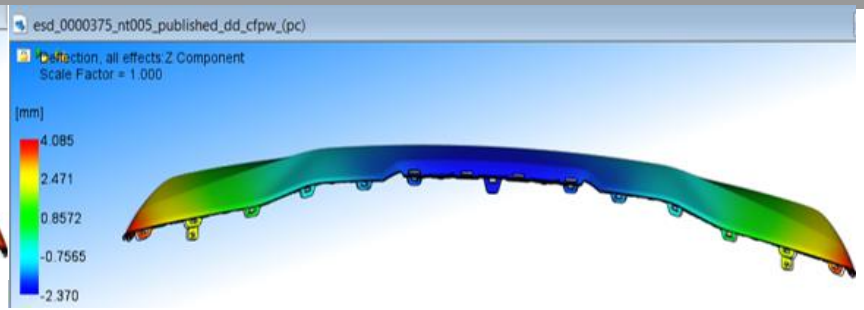
Large Deflection is not Applied to Dual Domain Model

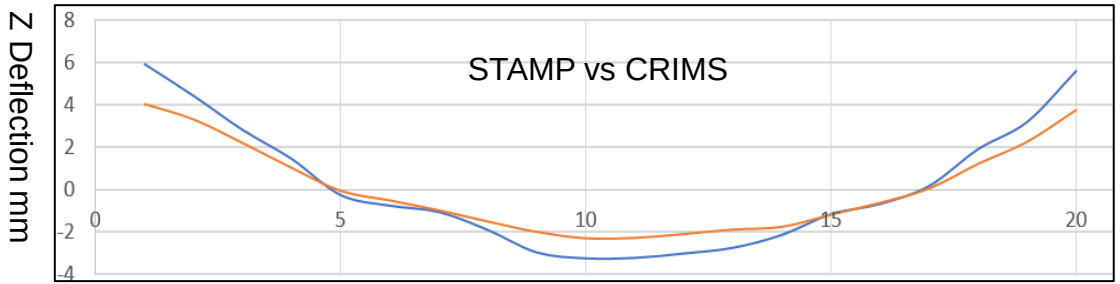


STAMP vs CRIMS - Example 1

Material Polycarbonate

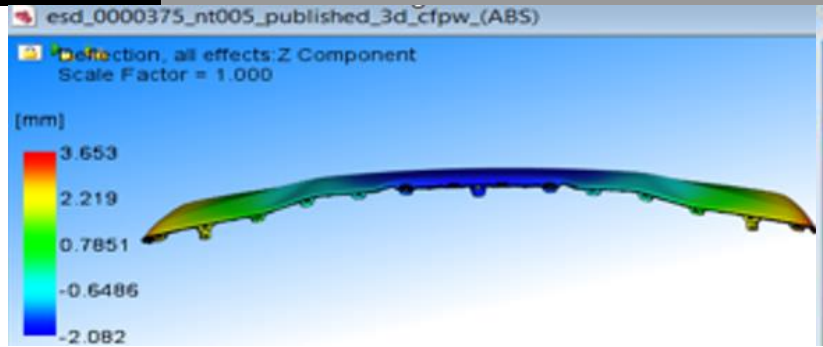


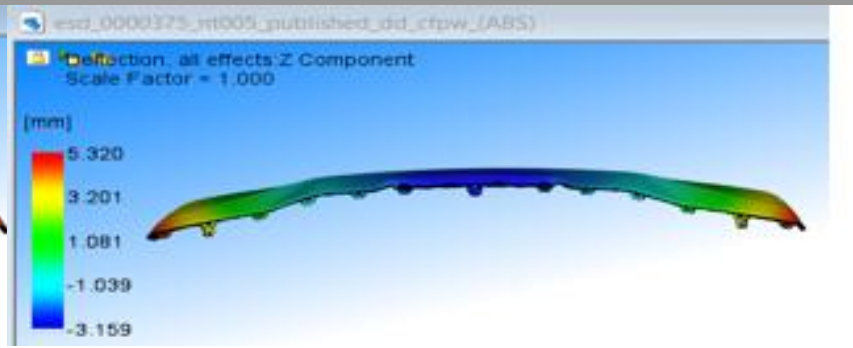


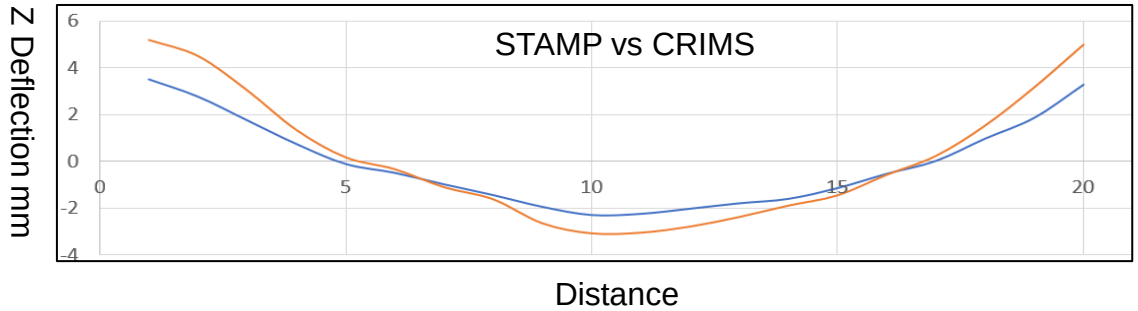


STAMP vs CRIMS - Example 2

Material ABS

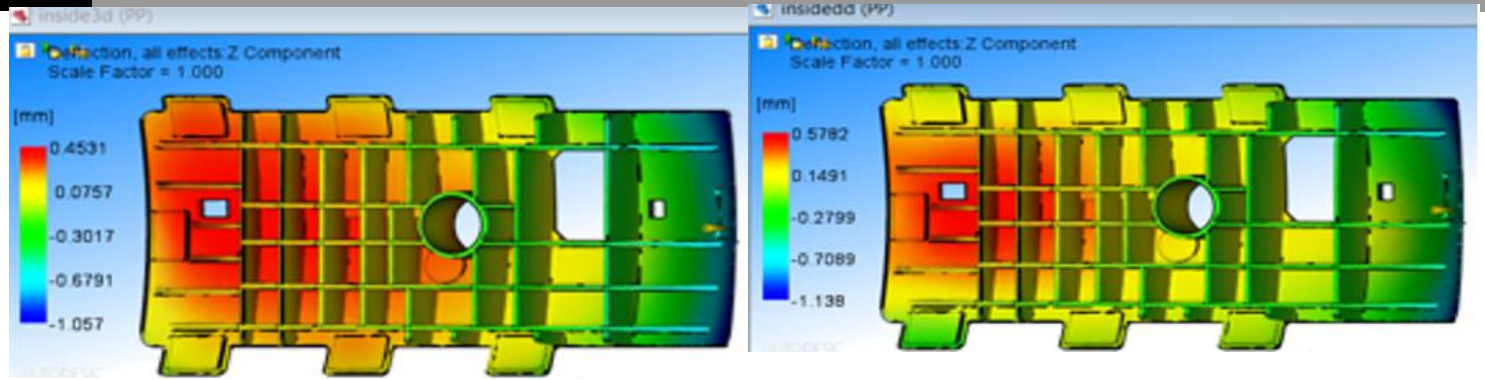


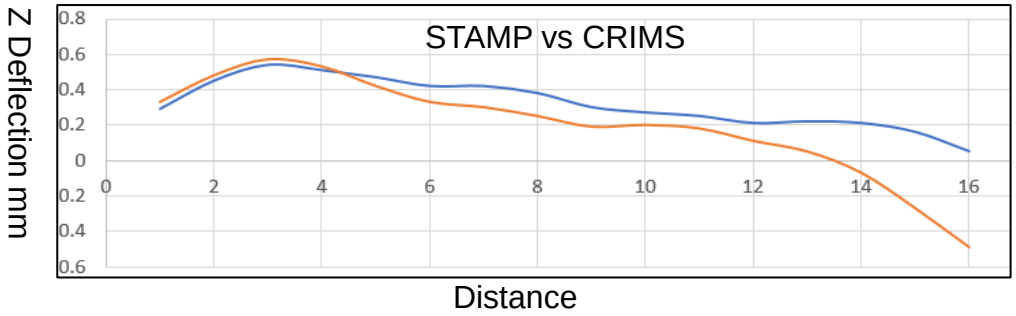




STAMP vs CRIMS - Example 3

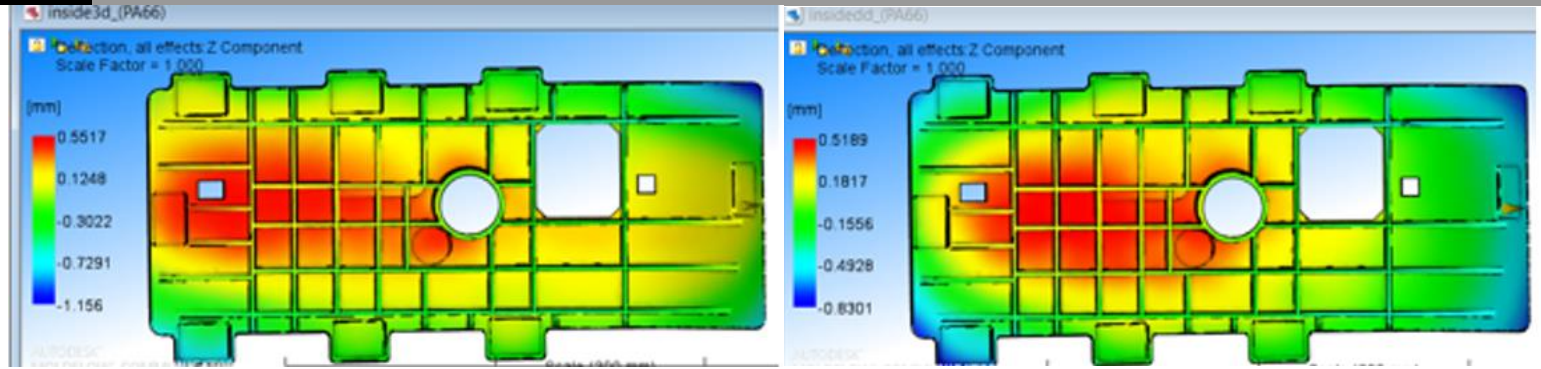
Material 35% Gless Filled PA66

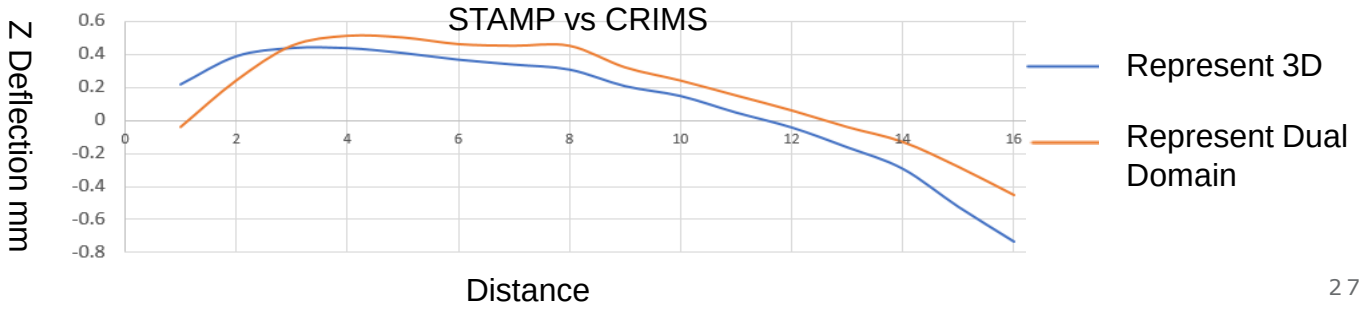




STAMP vs CRIMS - Example 4

Material 40% Talc Filled PP





Windage Concerns

Common Concerns/Reasons Against Windage

1. **Quality** – Part After Windage Does Not Meet Dimensional Requirements
2. **Cost** – Who Will Pay For Additional Design Work
3. **Time** – There Is No Time In The Program To Do This “Extra” Work

Doing Something And Being A Little Wrong Is Better Than Doing Nothing And Being Really Wrong

1. Implementing windage will result in parts closer to nominal than “hoping for the best”.

2. Modifying parts after windage may still be required, but less than without windage.

3. Improving accuracy will happen with more experience of including windage solutions.

GM Willing To Pay For Windage

1. Statement of Requirement includes upfront windage requirements and associated costs.

2. Any post-windage changes still needed are managed in same way as no windage.

3. Windage model officially agreed to by an “as-manufactured” layer in design release.

No Time In Program To Execute

1. Created extra complete mold design cycle (including water lines) prior to final release.

2. Developing standardized process with other enablers to meet program timing.

3. Identify windage need during program sourcing to focus collaborative efforts.

Conclusion

Windage Execution Enablers

1. Ensure Willing And Supportive Tier 1
2. Identify Design Risks Early (SOR)
3. Develop Strong Collaborative Relationships
4. Create Comprehensive Mold Design Early
5. Utilize Strategic Simulation Analysis
6. Generate Large Molding Window
7. Produce Robust Measurement & Data Analysis

Conclusion

1. Believe To Achieve
2. Develop And Communicate The Process
3. Archive Data
4. Define Strong Internal Moldflow Standards
5. Execute With Discipline
6. Continuously Improve (Kaizen)
7. Autodesk: Please Help To Improve Moldflow Deflection Solver

Acknowledgement


Thanks

Make Anything