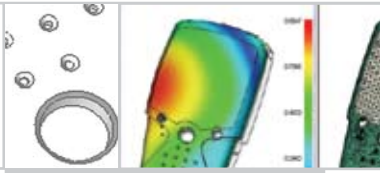
MPI/Warp



MPI/Warp provides users with an understanding of the causes of shrinkage and warpage in injection molded plastic parts and predicts where deformations will occur.

Results allow users to optimize design, material, and processing parameters to control part warpage before the mold is built. With MPI/Warp, even the most demanding application that requires high dimensional stability, excellent visual appearance, and accurate fit with mating components can be produced to quality, time, and budgetary specifications.

Capabilities

MPI/Warp allows you to:

- Evaluate final part shape before machining the mold
- Evaluate both single-cavity and multi-cavity molds
- Scale shrinkage and warpage results for better visualization of deformation
- Query any two points to determine any dimensional change between the two
- Constrain the part on a plane for better measurement of deflection
- Separate total displacement into X-, Y-, and Z-axis displacements to show only the deflection in each direction
- Show shrinkage and warpage as a visible displacement plot or as a color contour or shaded plot
- Export warp geometry in the STL format to use as a reference when sizing the mold
- Export warp mesh model for an iterative warpage analysis

Supported Model/Mesh Types:

- Finite-element midplane models
- Solids-based Fusion models (small deflection and single variate analyses only)
- True 3D solid models (small deflection and single variate analyses only)

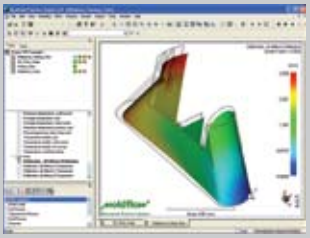
Supported Analyses:

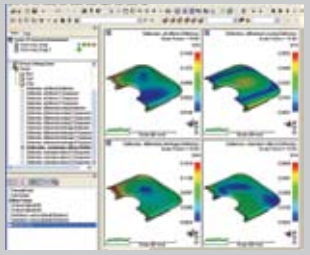
- MPI/Flow
- MPI/Fiber
- MPI/Gas (midplane models only)
- MPI/Co-injection (midplane models only)
- MPI/Injection Compression (midplane models only)
- MPI/MuCell®

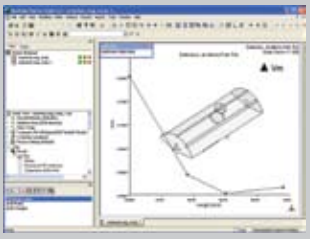
FEATURES

Residual Stress Analysis:

- Residual stress is calculated during the packing stage of the flow analysis when MPI/Warp is an available analysis option (currently not available for true 3D solid models):
  - Calculate residual stresses developing during the entire cycle, including effects of the temperature and pressure distributions, polymer properties, orientation, and geometric features of the part
  - Visualize the frozen-in stress through the part wall thickness
  - Determine stress prior to ejection (constrained by the mold) and after ejection (unconstrained)
  - Residual stress results are passed directly to the warpage analysis for use in calculating the final part shape







MPI/Warp Features

Linear Buckling Analysis:

- Predicts whether the part will buckle after ejection from the mold
- Large deflection analysis required if the part buckles

Small Deflection Analysis:

- Predicts the deformed shape if a linear buckling analysis shows the part is unlikely to buckle
- Useful for analyzing multiple design iterations

Large Deflection Analysis:

- Geometric non-linear large deflection
- Predicts the deformed shape after buckling
- Features load or displacement control
- Includes automatic selection of algorithm type and automatic step sizing
- Commonly used as a final check when the design is considered satisfactory

Single Variate Analysis:

- Isolates and predicts the effects on warpage of:
  - Molecular/fiber orientation
  - Cooling variations
  - Shrinkage variations
  - Corner effects
- The dominant cause of warpage can be quickly determined
- Works with small deflection and linear buckling analyses

Corrected Residual In-Mold Stress (CRIMS) Warpage Model:

- Uses layer-based, thermal and process-induced stress predictions calculated in the residual stress analysis
- Uses theoretical prediction to get a theoretical stress:
  - Viscous-elastic
  - No stress in liquid
  - No relaxation of stress in solid (no time dependence)
- Uses measured shrinkage data to correct the stress level and introduce anisotropy due to morphology development:
  - Molecular orientation
  - Orientation of crystalline material
  - Fiber orientation
- Corrects errors that may be present in material data:
  - pvT
  - Thermal coefficient of expansion
  - Elastic moduli

Solution Features:

- Based on viscous-elastic (instant freeze) model for both unfilled and fiber-filled materials
- Viscoelastic model based on thermorheologically simple assumption
- Composite property calculation based on existing models:
  - Tandon-Weng
  - Halpin-Tsai
  - Krenchel
  - Cox
  - Ogorkiewicz-WeidmannCounto
  - Schapery, Chamberlain, and Rosen-Hashin for thermal expansion coefficients
  - Advani-Tucker orientation model for thermo-mechanical properties
- Calculated residual stresses are corrected based on CRIMS model
- Coefficients are generated based on the measured data and calculated residual stresses
- Temperature and flow field asymmetry considered across the full thickness of the part
- Additional capabilities:
  - Automatic boundary condition generation
  - Capable of handling short-shot filling results

Results:

- Total deformation
- Deflection in the X-, Y-, and Z-directions
- Deflection history at any node
- Deflected component shape with exaggeration factor
- Buckling mode shape
- Elemental parallel and perpendicular shrinkage
- Elemental principal residual stress (midplane)
- Elemental Mises-Hencky stresses (midplane)
- Elemental maximum shear stress (midplane)
- Standard results from MPI/Flow, including Volumetric shrinkage
- Standard results from MPI/Fiber, including Thermo-mechanical properties of the composite material

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