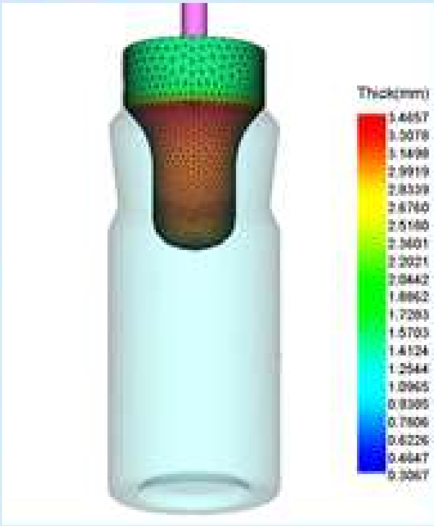
RheoWare Simulation Inc., a spin-off of

NRC·CNRC

Industrial Materials Institute

Webinar 2013-06-20

soft PROGRESS



Montreal, Quebec, Canada

National Research Council Canada

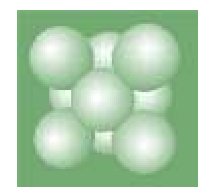
Conseil national de recherches Canada

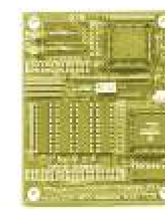
Canada

RheoWare at a glance

- RheoWare Simulation Inc. is a spin-off of NRC for commercialization of Blowview & FormView in Europe and Asia

- BV/FV is process simulation and modelling tools technology, developed by the Industrial Material Institute (IMI) of National Research Council of Canada (NRC):
  - Over $40M invested in software development since 1990
  - A consortium of more than 20 industry leaders involved in the software development





RW
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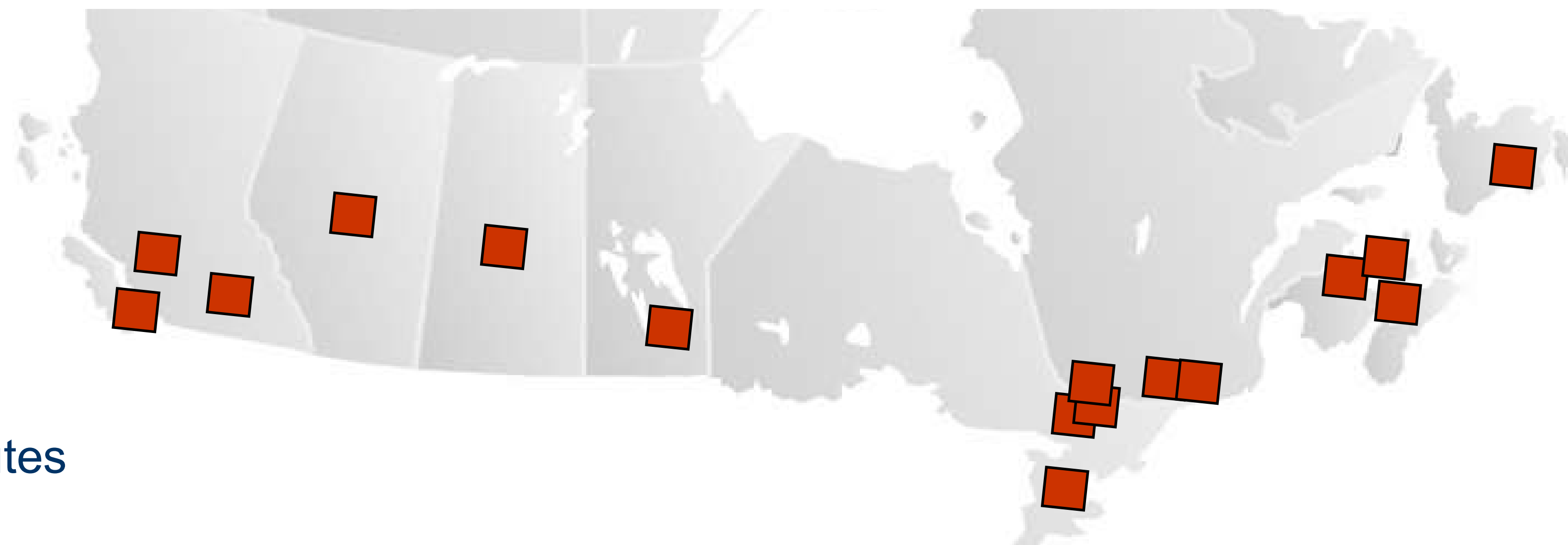
National Research Council Canada

- As Canada’s principal public R&D organization carrying out scientific and technical work, the NRC will play a leading role in developing an innovative and knowledge-based economy
- 20 research institutes
- 4,000 + employees — 1,200 guest researchers
- $800 million budget — $100 million income



Institutes

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NRC-IMI Incubation of Technology-Intensive Firms

- 24,000 sq. ft. of office and lab space
- 22 companies in incubation

6 Key Sectors

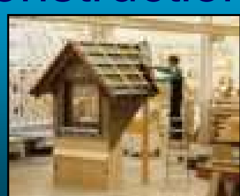
Transport

Plastic Industry

Packaging

Sectors where
BlowView and FormView
can make a significant contribution

Construction



Medical

Automotive

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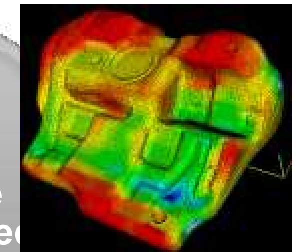
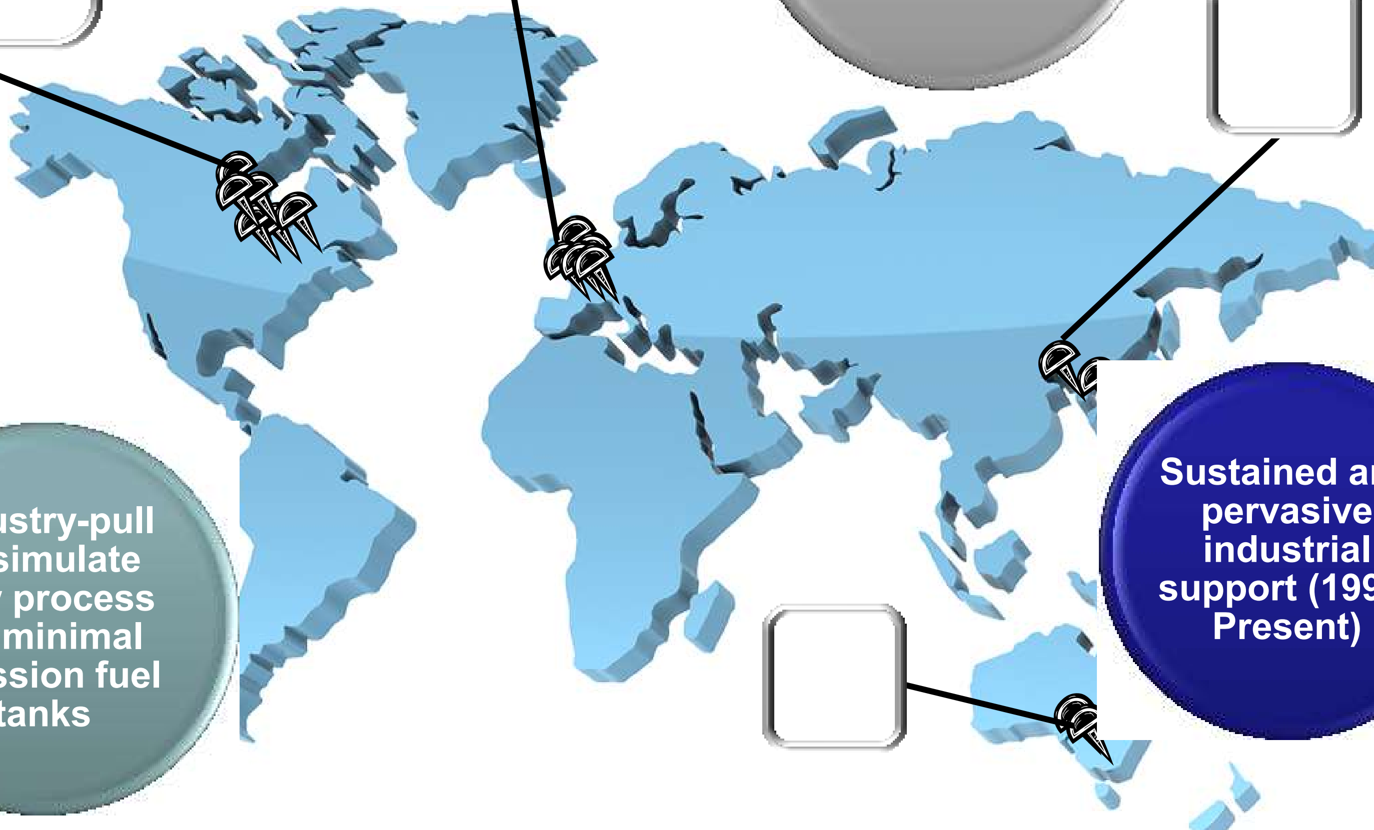
Industrial Users



Majority of plastic fuel tanks in the world designed with NRC simulation



Industry-pull to simulate new process for minimal emission fuel tanks

Sustained and pervasive industrial support (1992-Present)

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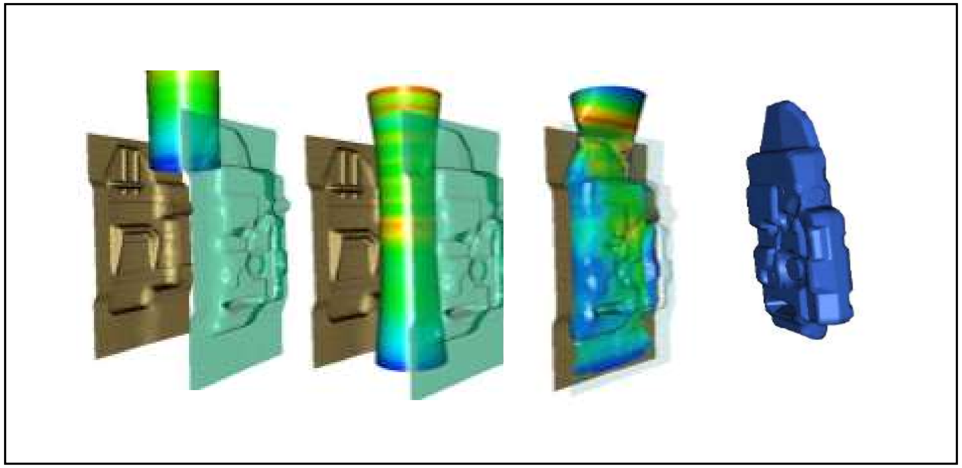
BlowView & FormView

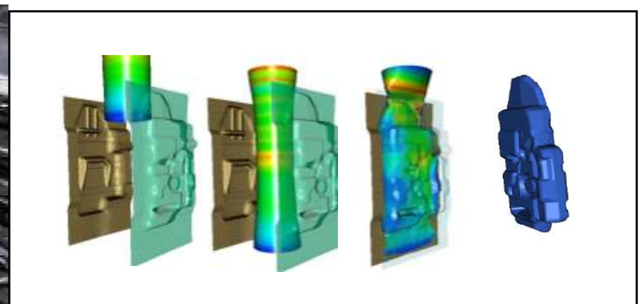
➢BlowView and FormView are finite element analysis tool capable of predicting parison / preform / sheet deformation in extrusion blow molding, stretch blow molding and thermoforming applications.

➢Software is useful for engineers, technicians, mold makers and resins manufacturers etc.



Competitive Advantage

- Finite element solver specifically for plastic industry
- Precise, fast, 10x faster than other commercial software
- Solves day-to-day problems in industrial manufacturing
- Digital moulding and optimization through the consideration of material characterization
- Developed by an innovative and advanced R&D institute (IMI) for more than 20 years
- Used and validated by more than 50 industry leaders in Europe, North American and Asia

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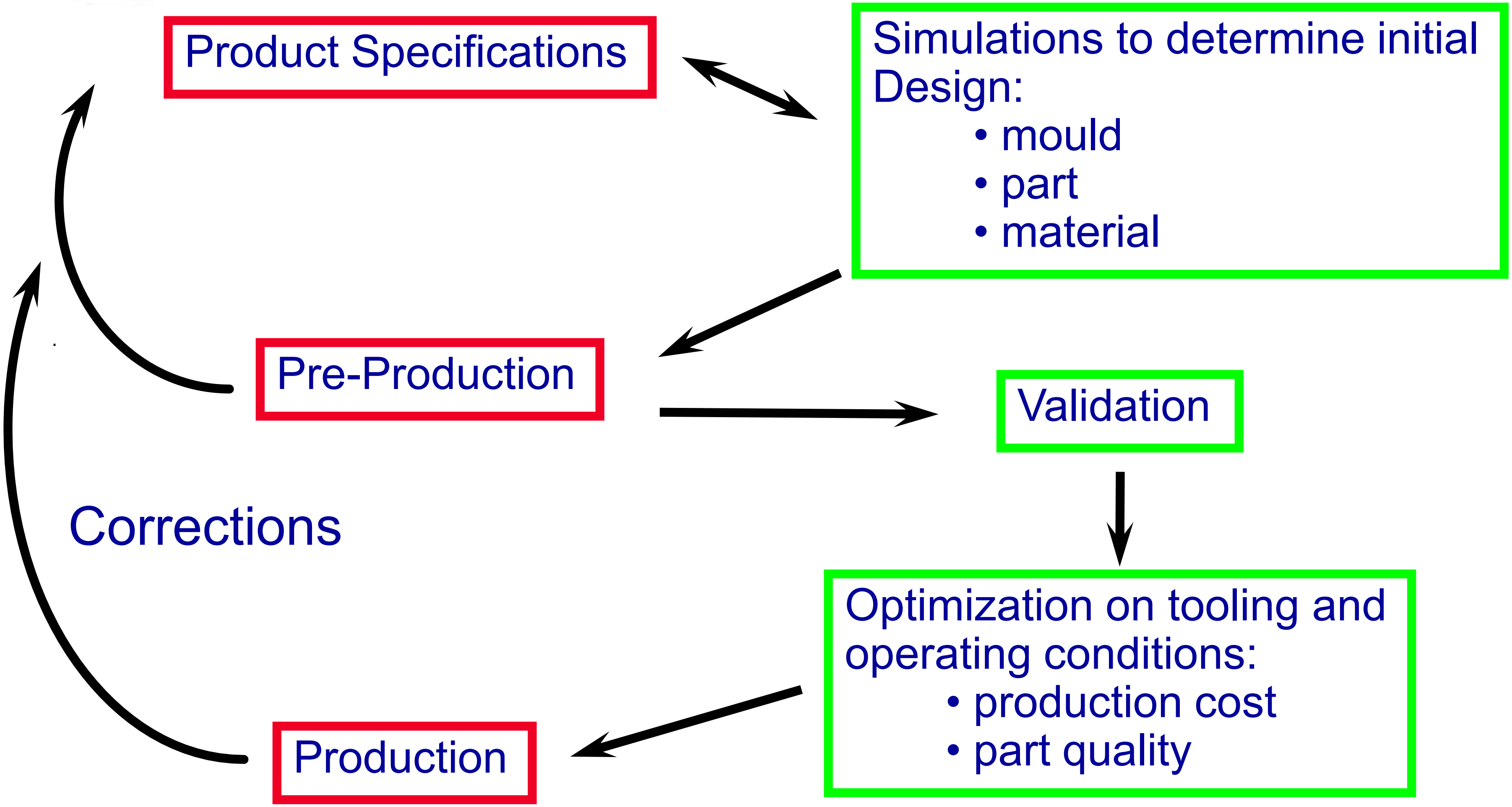
Simulation in Product Development



Extrusion Blow Moulding (EBM)

Simulation

EBM Process Simulation

Process simulation:

- ❑ Flow in extrusion dies
- ❑ Parison sag
- ❑ Mould clamping
- ❑ Parison inflation
- ❑ Part cooling
- ❑ Part shrinkage and warpage

Additional options:

- ❑ Coupled effect of sag and swell in parison extrusion
- ❑ Effect of die geometry (Possibility of simulating different types of die)
- ❑ Monolayer, multilayer and 3D blow moulding
- ❑ Extrusions at non-uniform gap
- ❑ Design advisor for multi-objective part development
- ❑ Non-isothermal effects
- ❑ Prediction of forming defects (webs and folds)

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EBM Parts Simulation

Old and new Booster Seat comparison:

- 25% Weight Reduction
- 10% Cycle Reduction
- Quality Improvement

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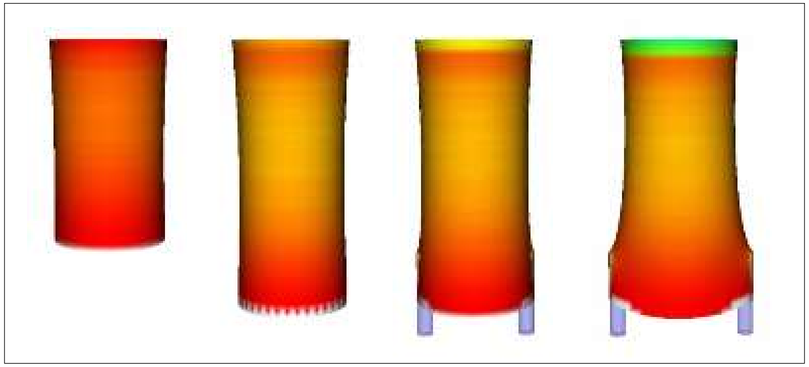
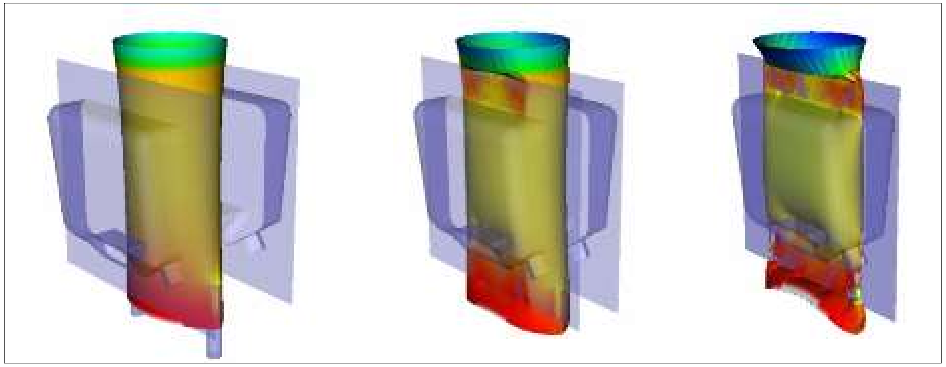
JERRY CAN

EBM Process Simulation

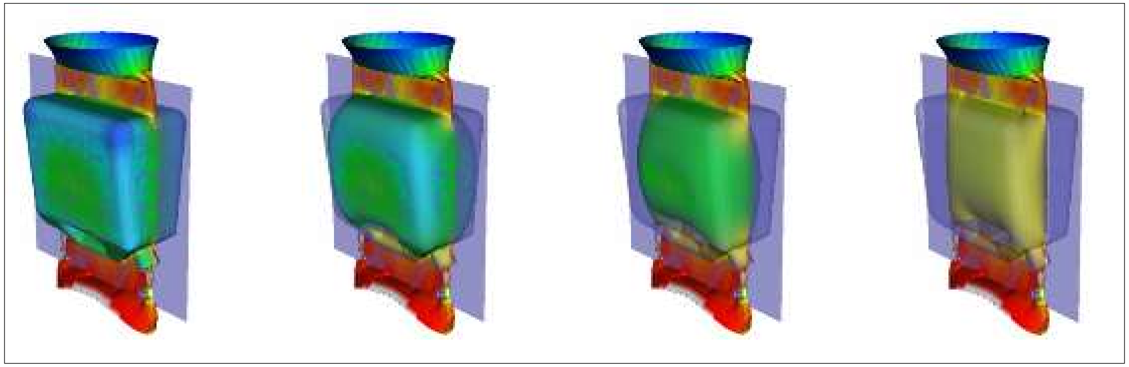
Integrated phases



Parison Extrusion and Stretching

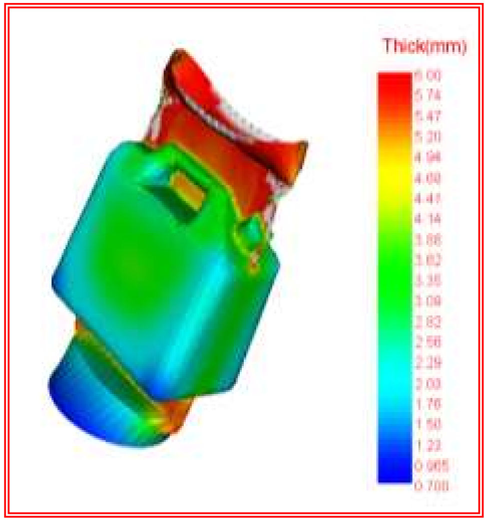


Mould Displacement



Parison Blowing

Final Part Thickness



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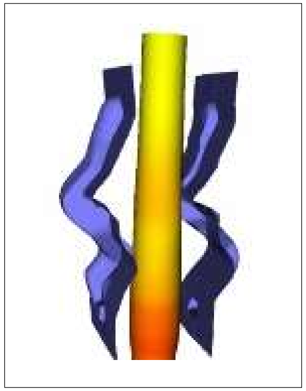
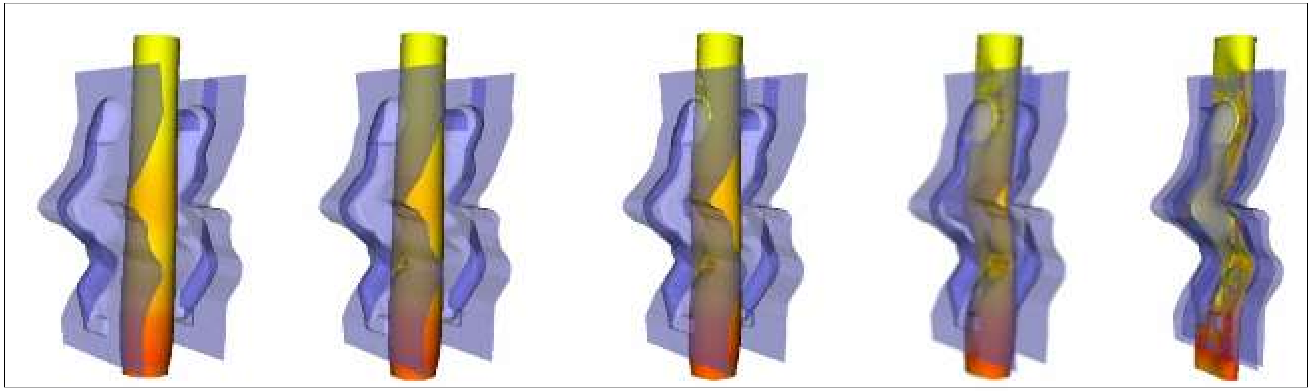
Air Duct

EBM Process Simulation

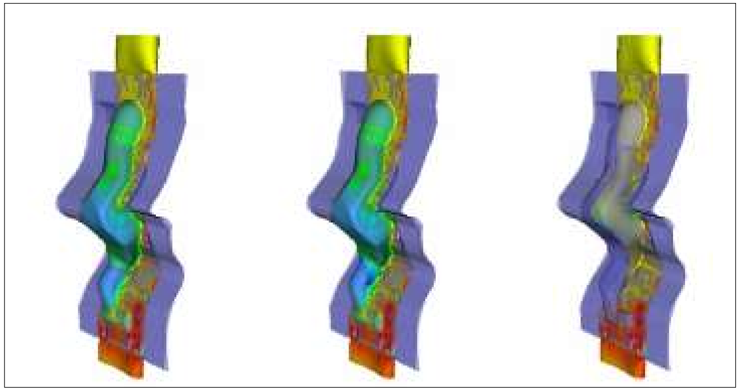
Integrated phases



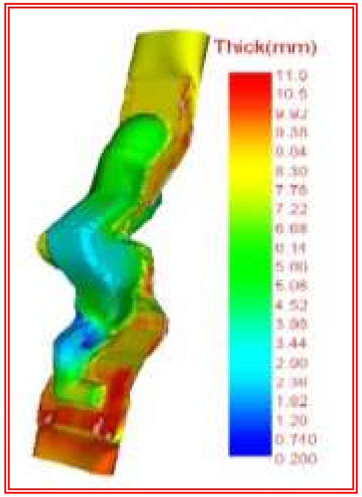
Parison



Mould Displacement



Parison Blowing



Final Part Thickness

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Extrusion Blow Moulding

Simulation Case Study

Modeling and Optimization of Blow Moulded Parts

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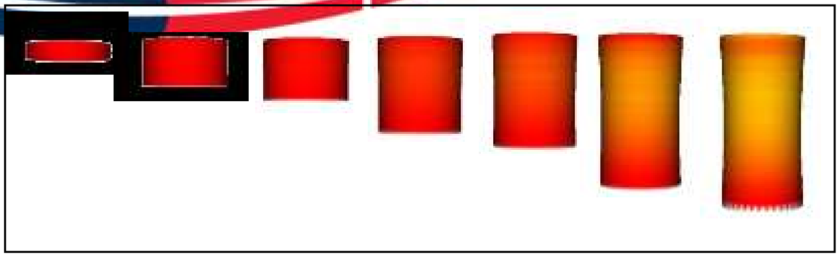
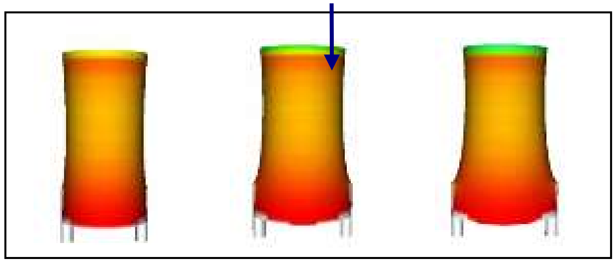
BlowView Software

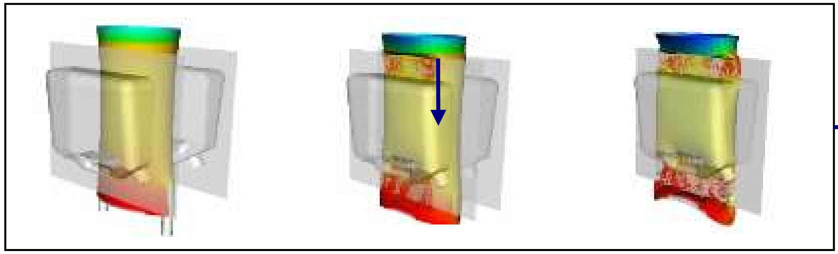
EBM Process Simulation Integrated phases



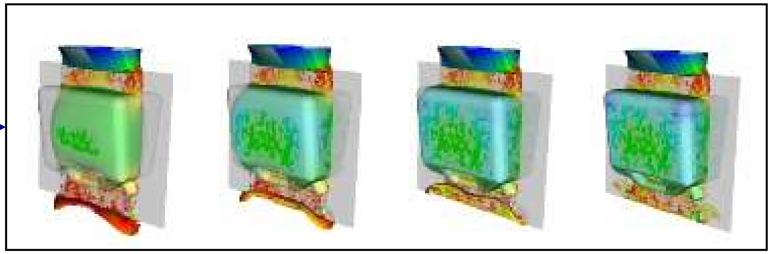
1. Parison Extrusion



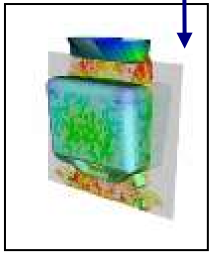
2. Parison Stretching



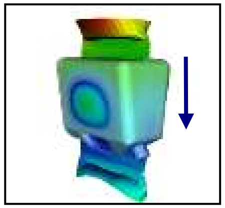
3. Mould Traveling & Clamping



4. Part Inflation



5. Part Cooling



6. Part Warpage

Fuel Tank

Part	*Case Study*	*Operating Conditions*	*Material Properties*
		*Flow rate* = 270 g/s *WE No.* = 1 – 30 *Length* = 1700 mm	*HDPE – 4261* λ_u = 6 s η_0 = 330 kPa.s

η_0 = Zero-shear viscosity

$$WE = \frac{Q\lambda}{A_{die} h_{die}}$$

$$\lambda_u = \eta_0 J_S^0 = \eta_0 \frac{\sum G_i \lambda_i^2}{\left(\sum G_i \lambda_i\right)^2}$$

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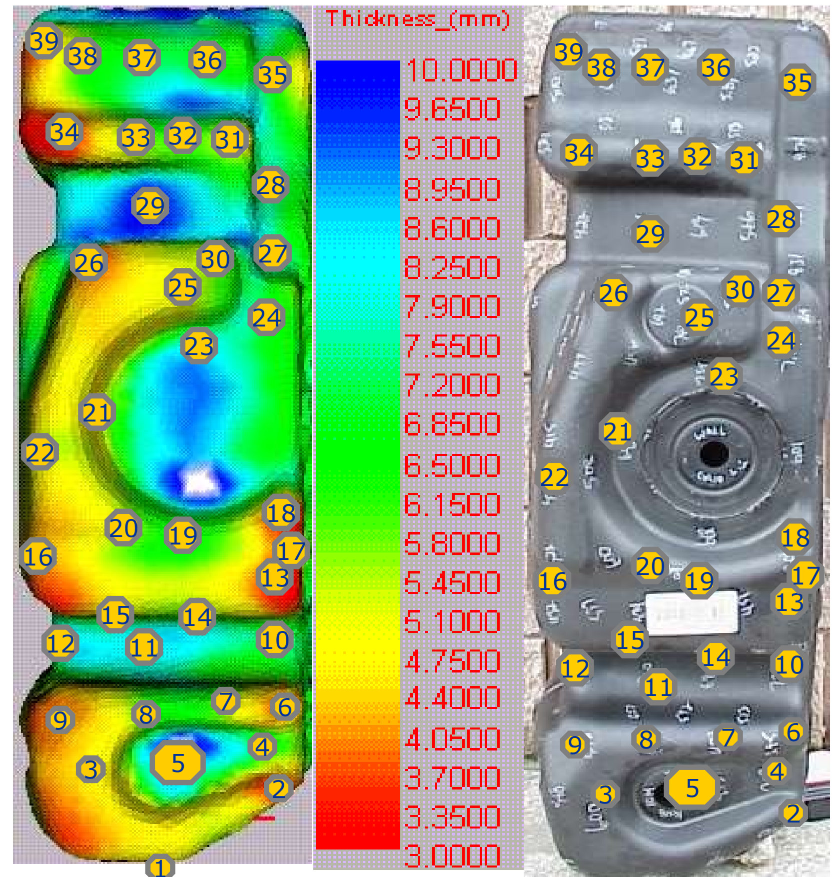
Part Thickness (Experimental vs. Simulation)

The exact physical process parameters were used for the virtual simulation to predict the distribution.



Comparison between physical and virtual EBM shows good agreement.

Error Estimation (Experimental vs. Simulation)

Variable	Physical Prototype	Simulation Prototype	% Error
Flow Rate (Kg/hr)	888.6	872.5	1.8
Cycle Time (s)	57.1	56.1	1.7
Shot Weight (kg)	13.81	13.91	0.7
Part Weight (Kg)	9.995	9.91	0.8
Flash Weight (kg)	3.82	4.00	4.7
Minimum Thickness (mm)	3.04	3.06	0.6

Physical and virtual EBM comparison shows over *95%* accuracy.

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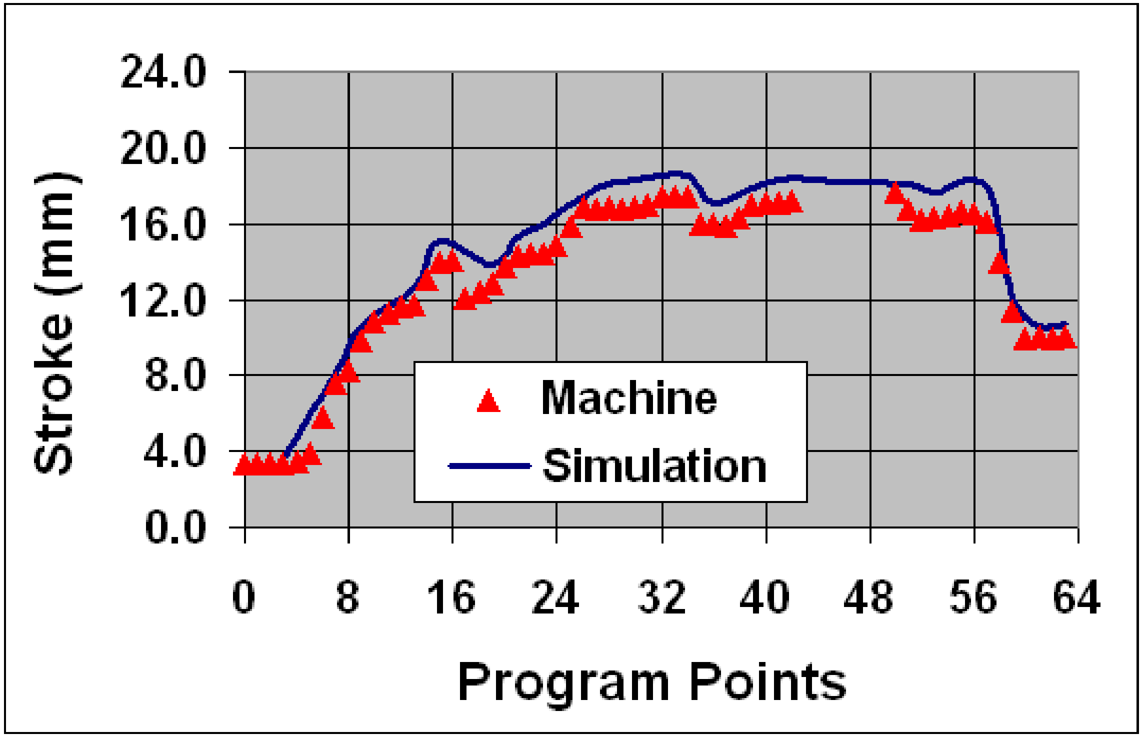
Machine Stroke (Experimental vs. Simulation)

- ***Program points from simulations can now be readily used as a starting point for machine profile settings.***



Elimination of trial-and-error approach resulted in lower labor & faster delivery.

Uniform Part Thickness

Objective Targeted: Uniform part thickness = 3.0 mm

Design Variables: *Gap opening, Maximum die gap, flow rate, stroke motions*

Parison length: *430 mm*

Extrusion time: *30 sec*

No of prog. points: *10*

Initial gap opening *60%*

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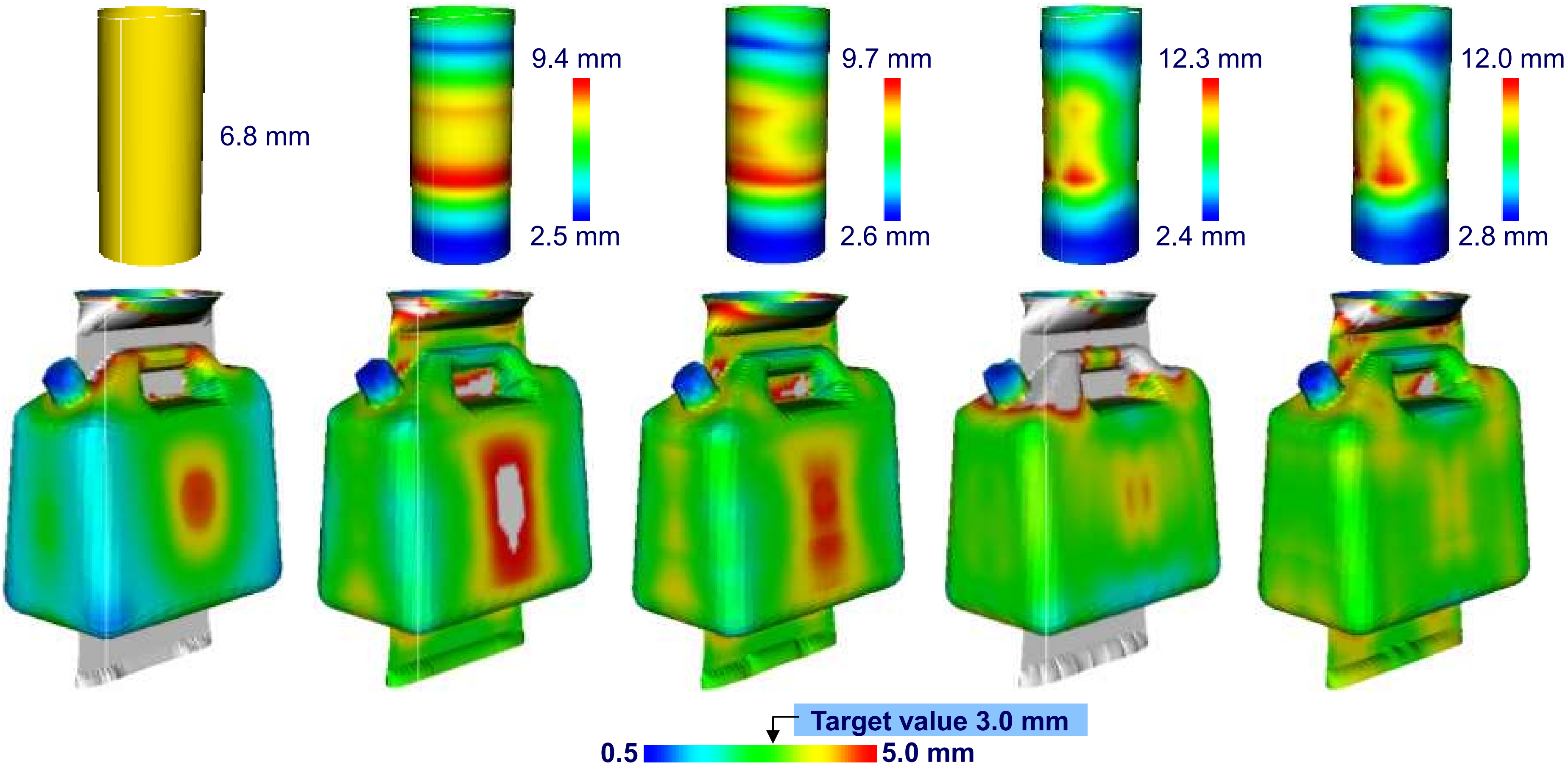
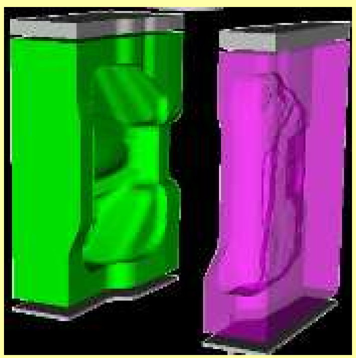
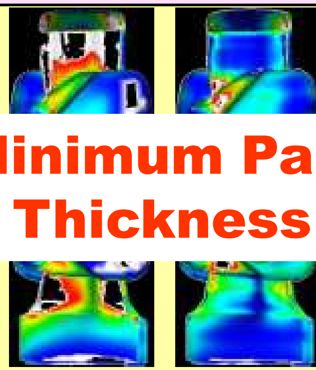
Optimization Results

	Initial Design	VWDS	VWDS+PWDS	VWDS+SFDR	VWDS+SFDR+PWDS
σ	0.83	0.63	0.51	0.45	0.4
$\bar{T}$	3.38	3.02	3.03	3.06	3.1



Minimum Part Thickness

Part	Case Study	Optimization Strategy	Material
	 Minimum Part Thickness	VWDS	Generic HDPE

Minimum Part Thickness

Objective Targeted: Minimum part thickness = 3.4 mm *(before shrinkage)*

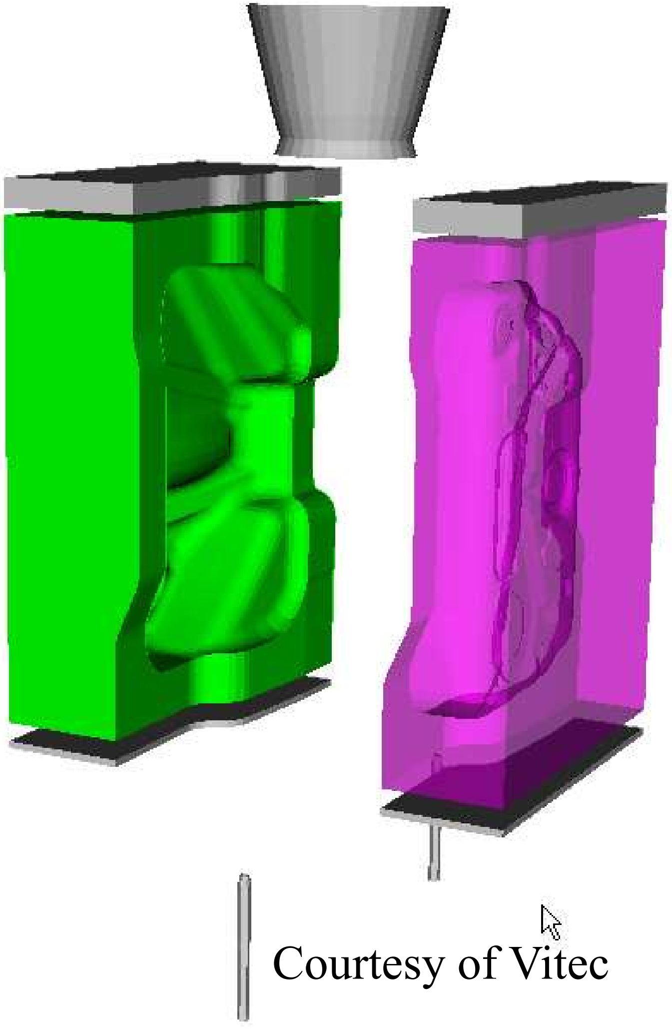
Design Variables: *Gap opening, flow rate*

Parison length: *1405 mm*

Extrusion time: *120 sec*

No of prog. points: *64*

Initial gap opening *50%*



Courtesy of Vitec

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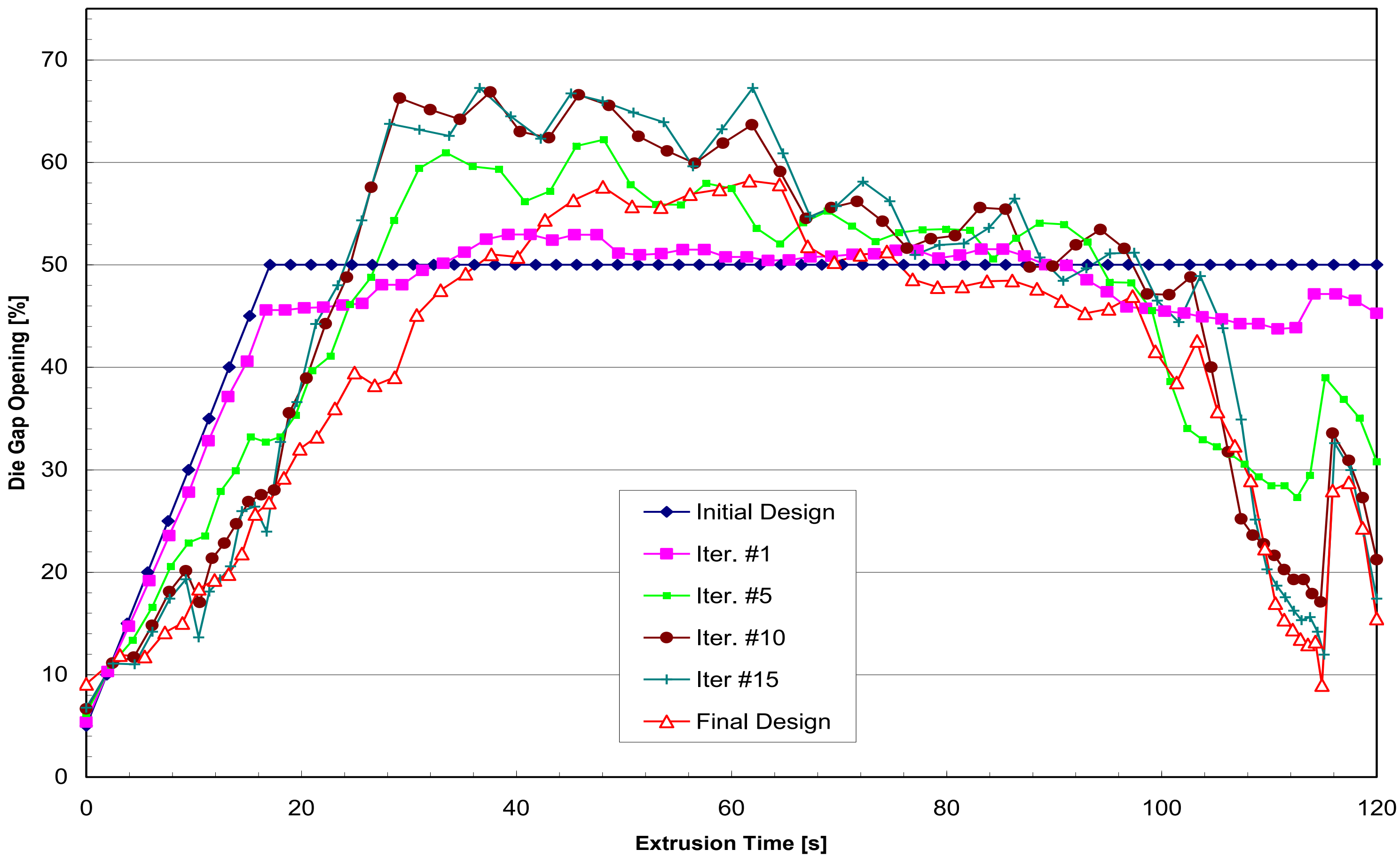
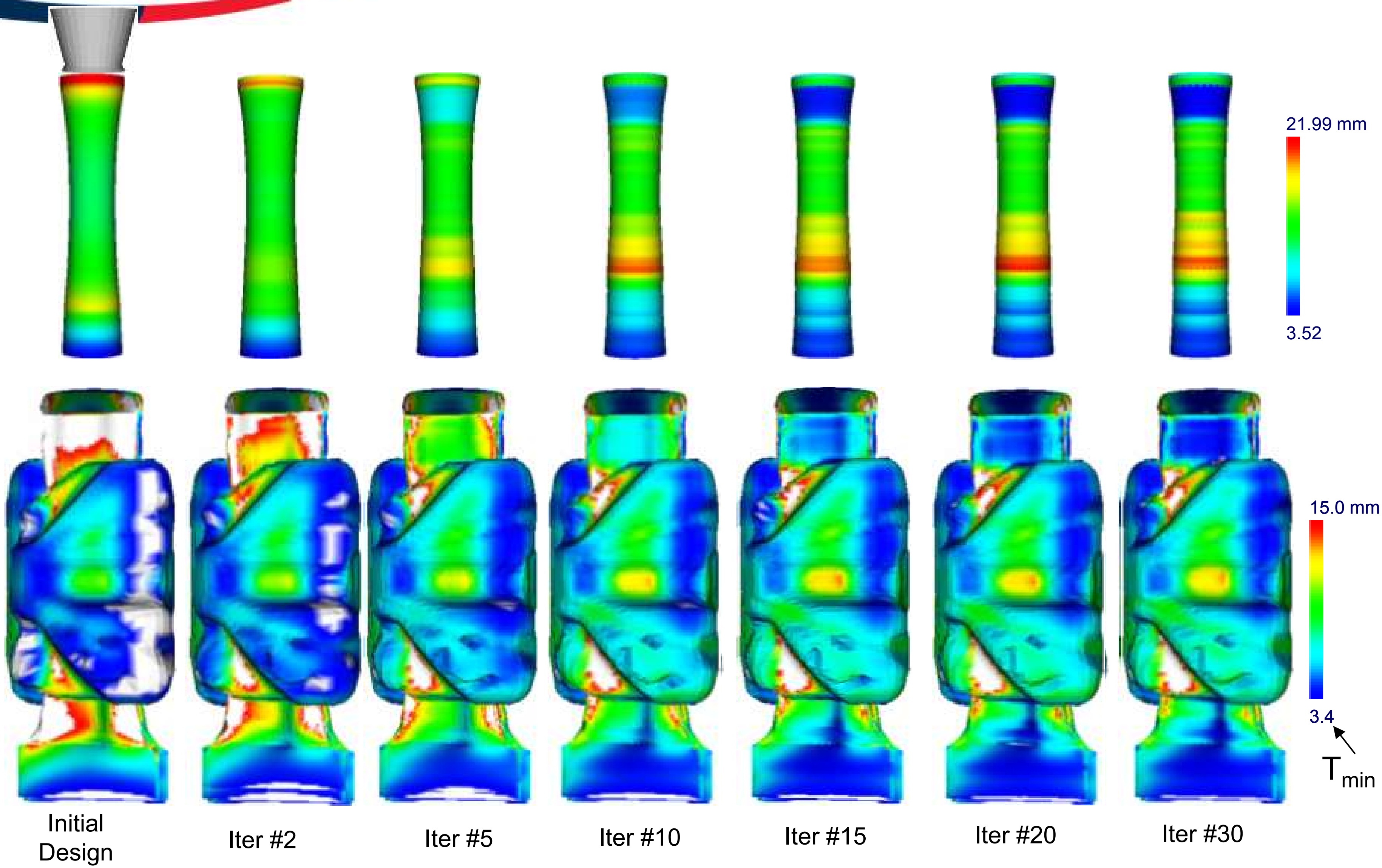
Optimization Results



Optimization Results



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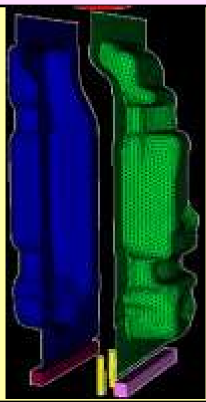
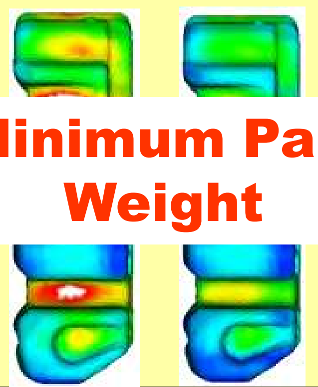
Minimum Part Weight

Part	Case Study	Optimization Strategy	Material
	 Minimum Part Weight	VWDS	Generic HDPE

Minimum Part Weight

Objective Targeted: **Minimum part weight**
(Minimum part thickness = 3.0 mm)

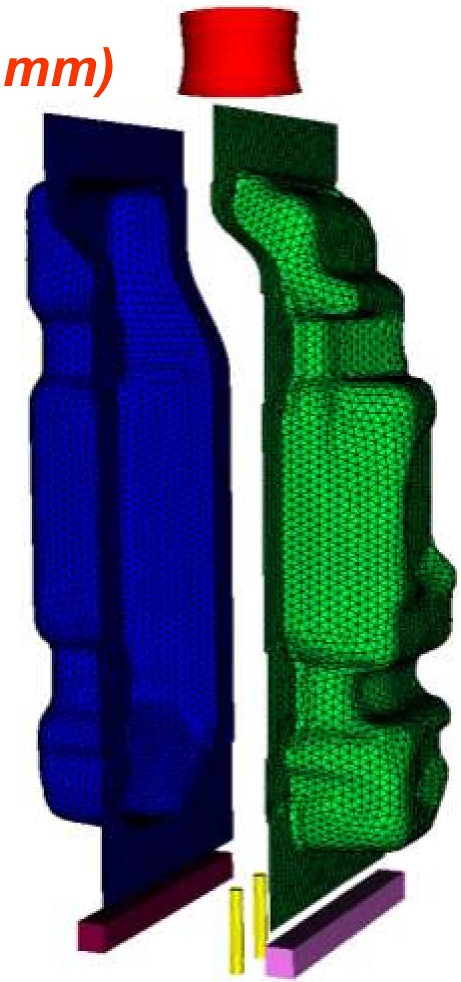
Design Variables: *Gap opening,*
flow rate

Parison length: *1550 mm*

Extrusion time: *56.1 sec*

No of prog. points: *64*

Initial gap opening *Slide 21*



Courtesy of Kautex

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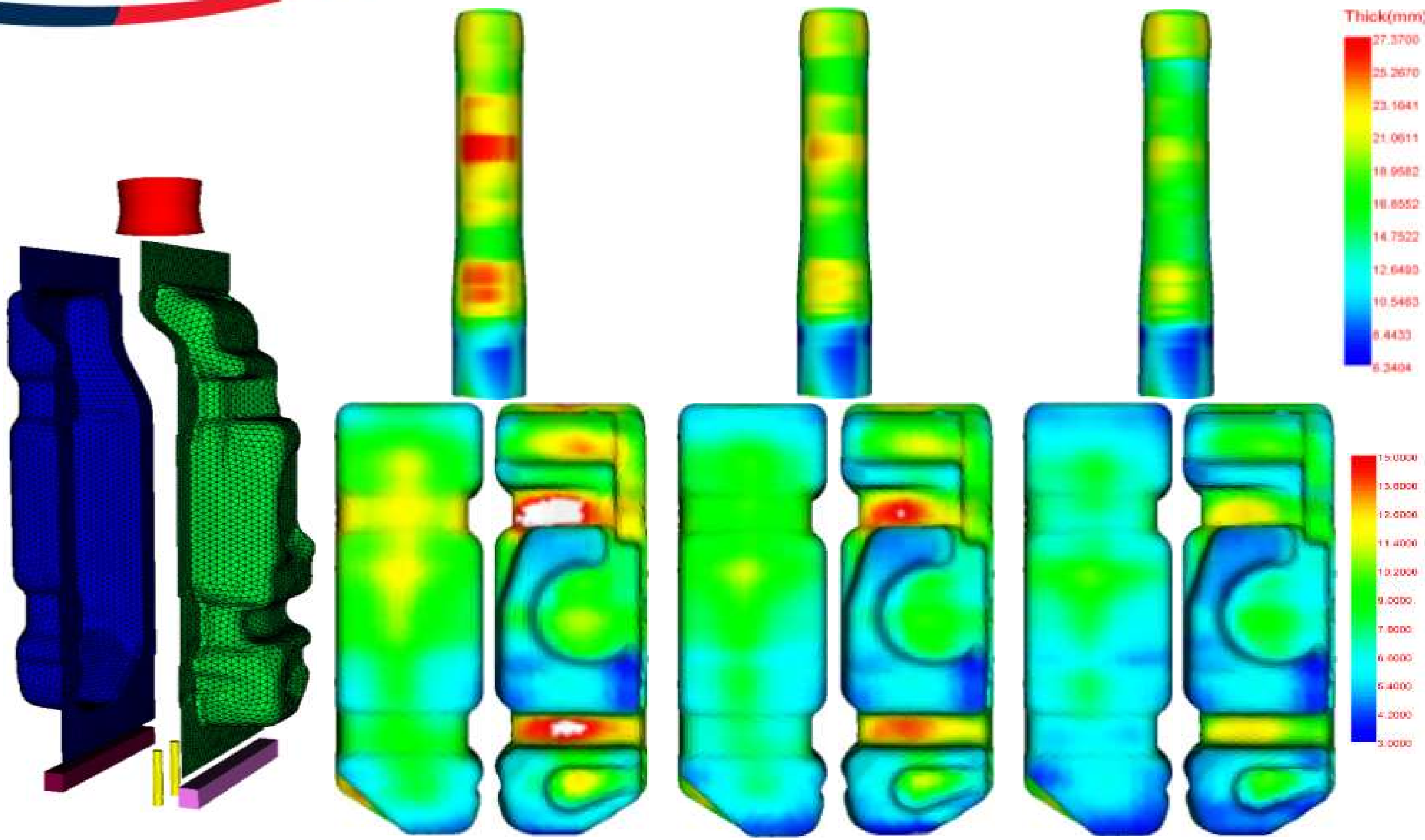
Optimization Results



Initial design
13.1 kg

Iteration #1
11.5 kg

Iteration #2
10.2 kg

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Thermoforming (THMFG)

Simulation

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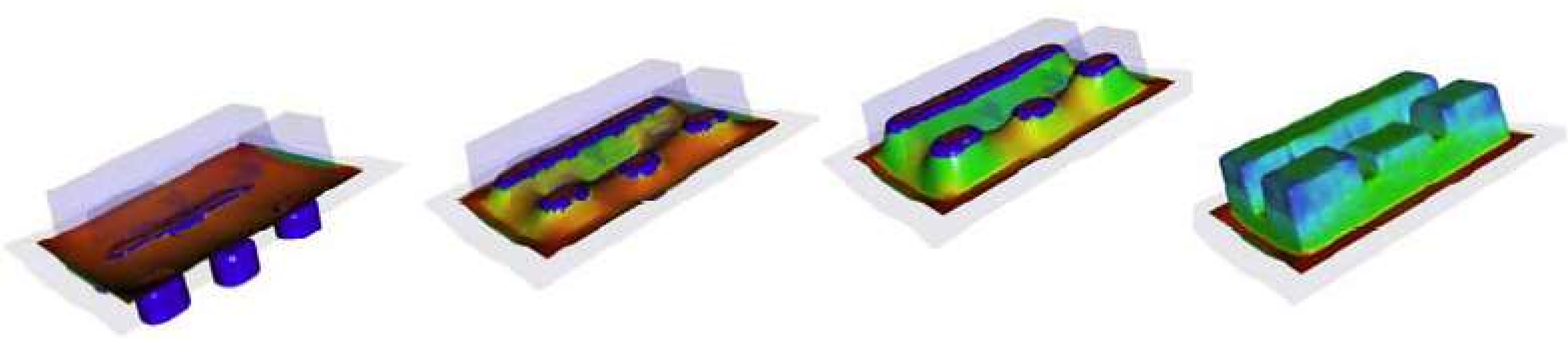
Forming Processes

Thermoforming

- Transportation, electronics, construction, packaging
- Car doors and windows, electronic housings, baths, signs, trays and containers



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Thermoformed Parts



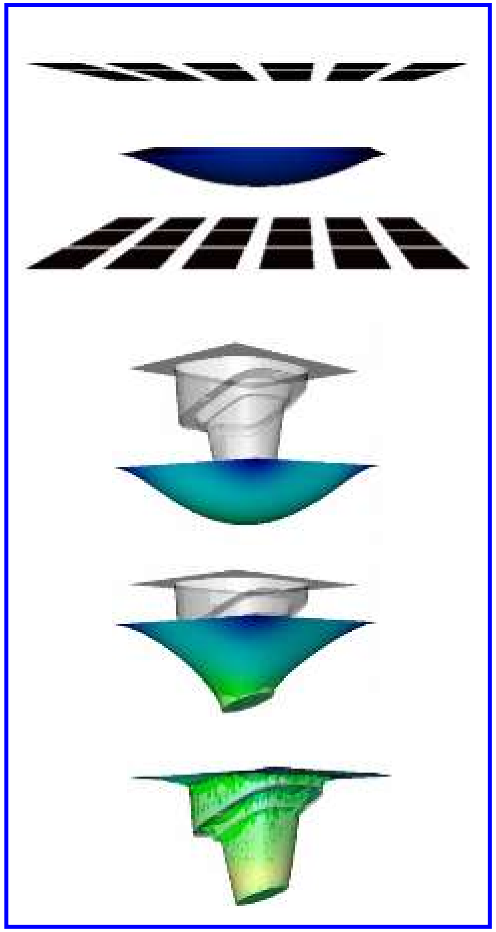



Software Capability

Thermoforming Simulation

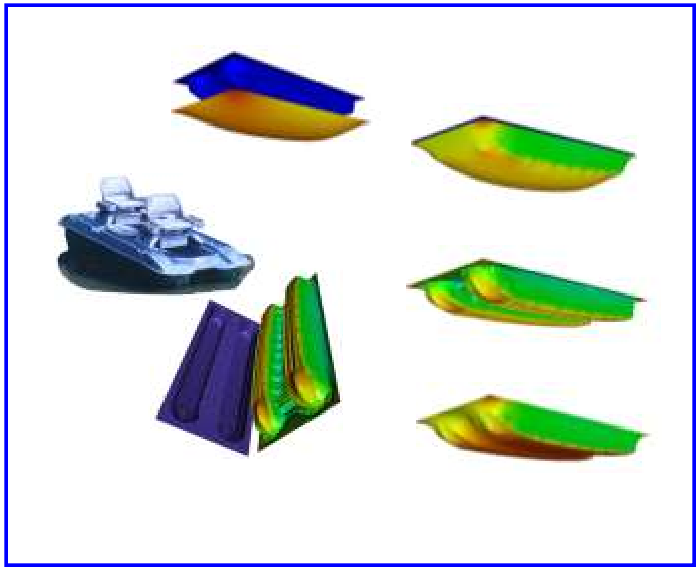
- Process:
  - Sheet reheat by radiation
  - Sheet stretching and forming
  - Part cooling
  - Part shrinkage and warpage

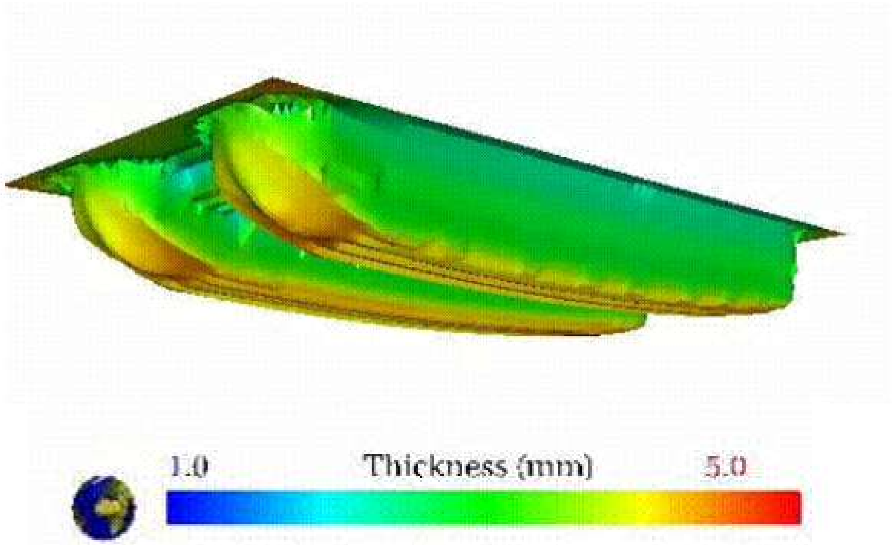
- Additional options:
  - Local mesh refinement
  - Vicoelastic and hyperelastic models for large deformations
  - Non-isothermal effects
  - Prediction of forming defects (webs and folds)
  - Plug effect including slip
  - Monolayer, multilayer, twin sheet and 3D thermoforming



Thermoforming Case
Boat Base

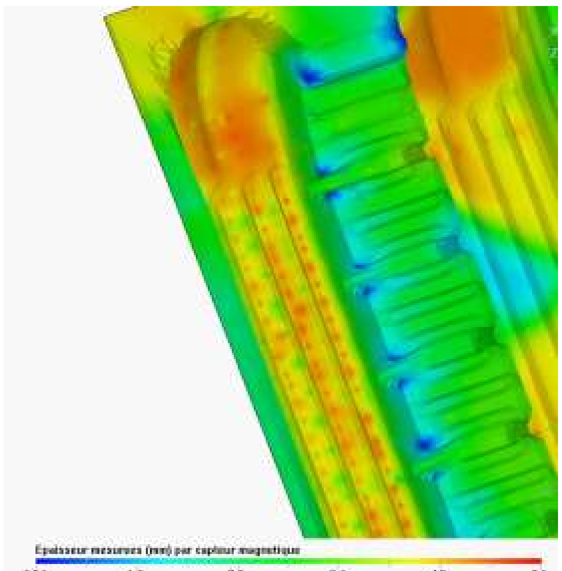
Boat base



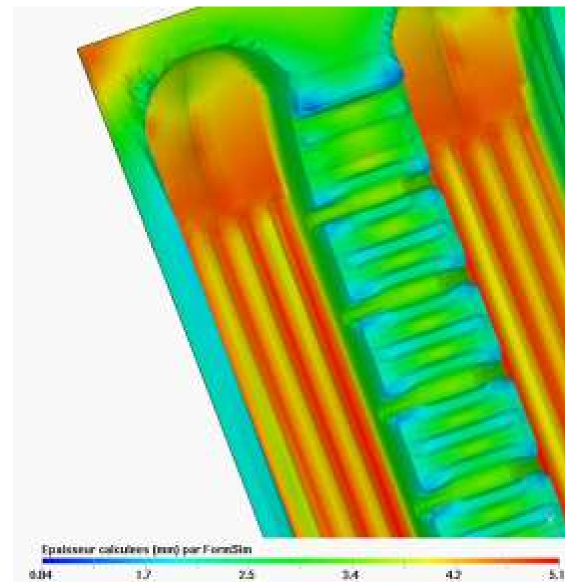


Boat base-validation

Thickness measured with magnetic gage



Thickness predicted by FormView

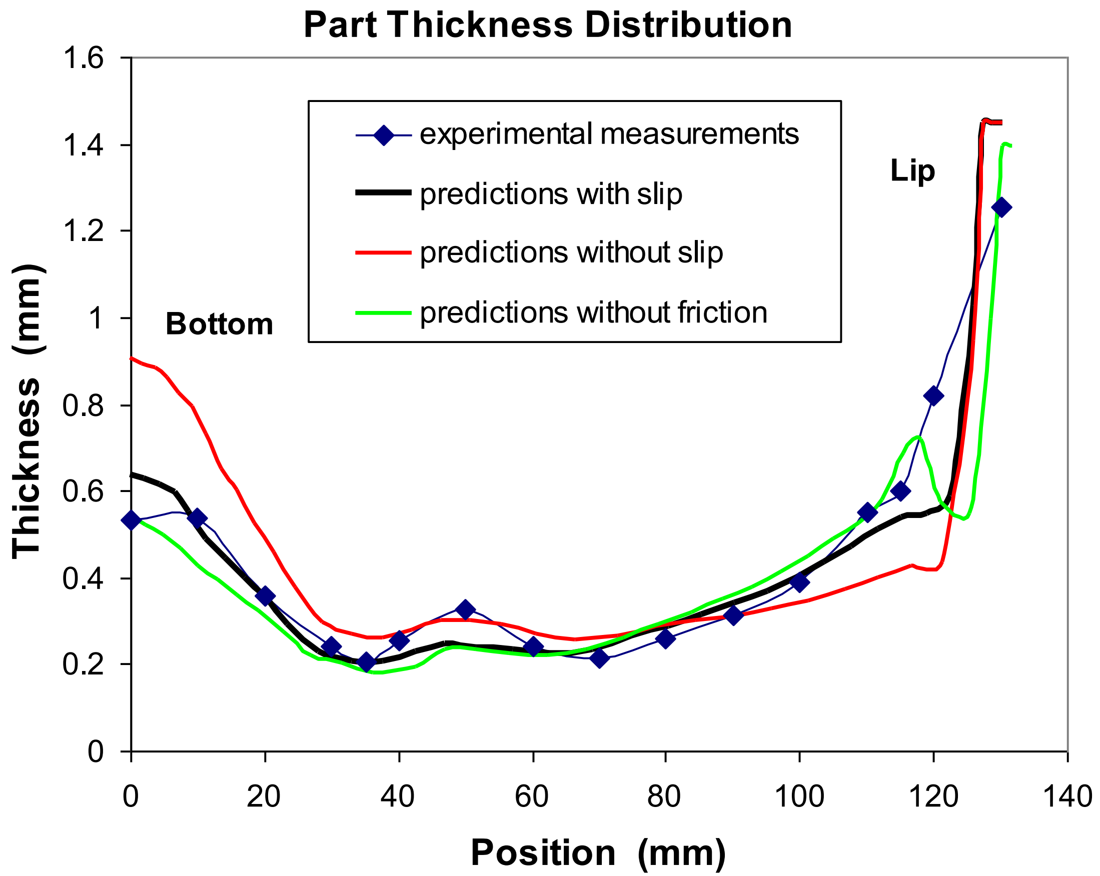


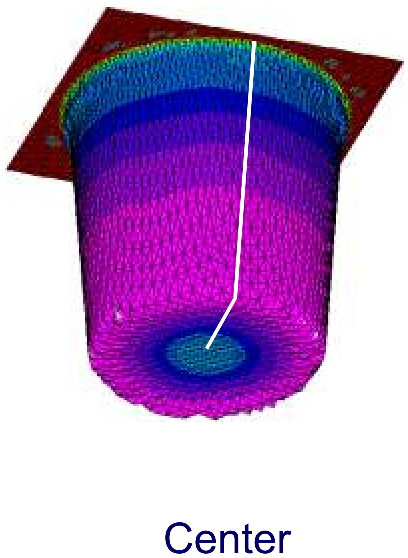
The simulation predicts accurately the real process.

Thermoforming Food Container

The software has a slip function.

Simulation with slip provides more accurate results.





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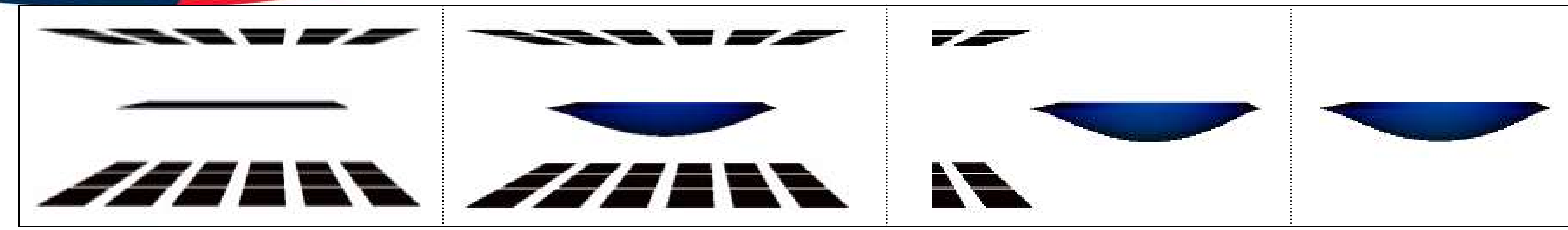
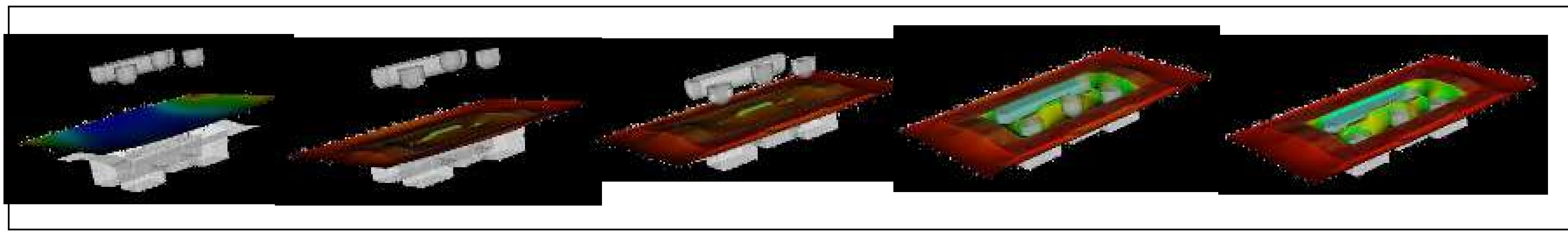
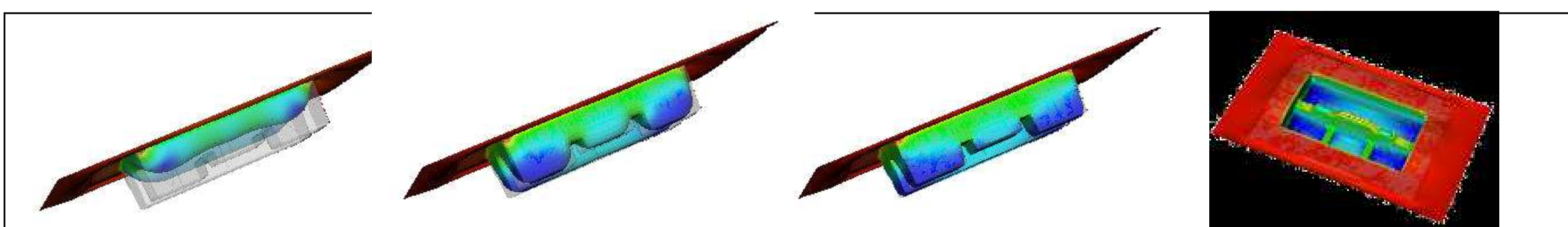
Plug-Assisted Thermoforming Simulation



1-2. Sheet Heating and Transfer



3. Mould & Plug Displacement

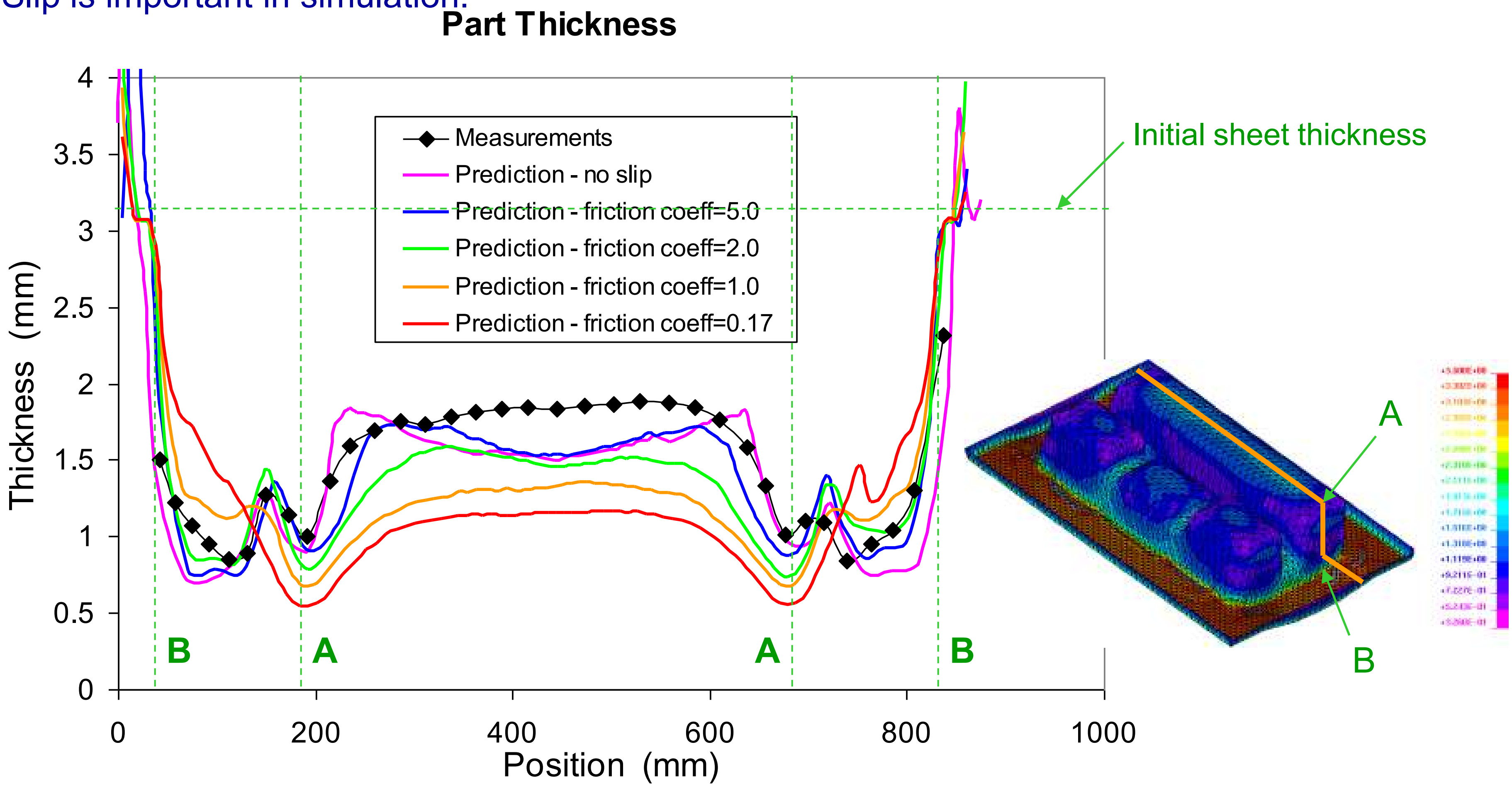


3. Vacuum Forming

Thermoforming Plug-Assisted
Case: Toolbox

Different coefficient of slip will provide different results.

Slip is important in simulation.



How To Run Simulation

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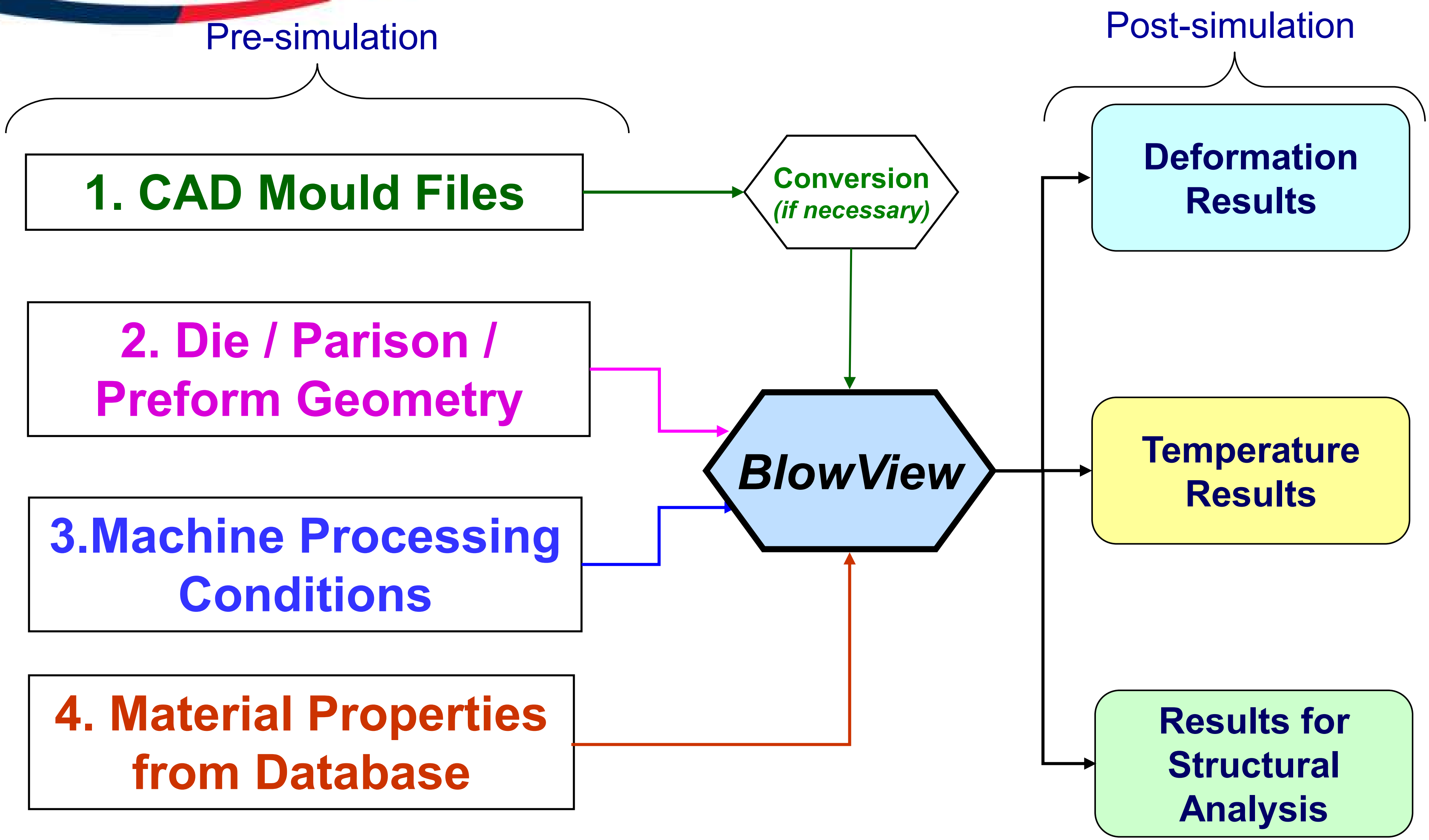
Simulation Process

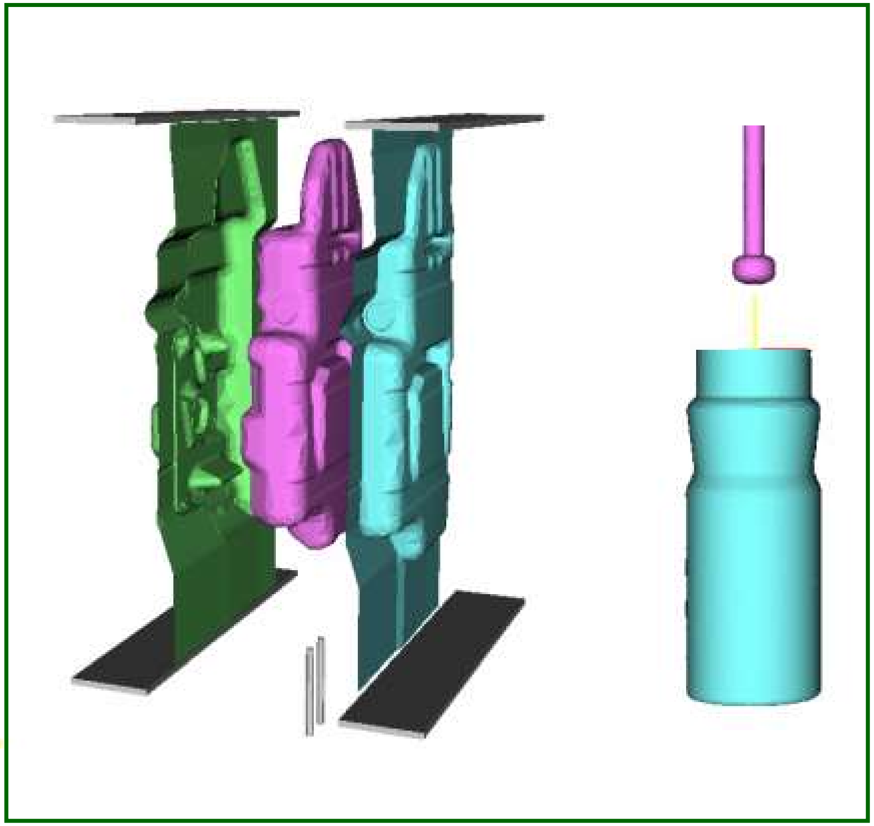


Mould Design

- Mould & part design by one of following CAD Systems:
  - Unigraphics
  - Catia
  - ProEngineer
  - Ideas
  - Amira
  - Ansys
  - AutoCAD
  - Solidedge
  - SolidWorks
  - Cimatron
  - Other domestic software

  - Requirement
  - Design a preliminary mould containing just the cavity
  - All other equipments (pinch plates, rod) must also be drawn in CAD
  - Moulds must not have any holes

Moulds and parts



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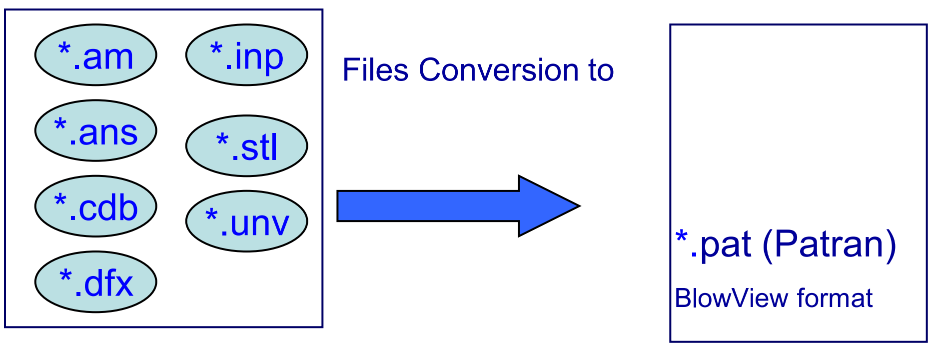
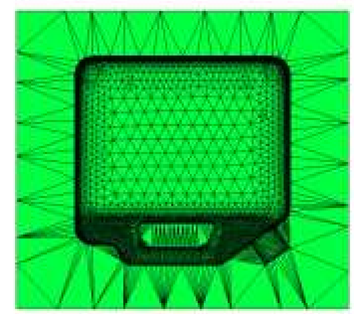
CAD Files Conversion

- Output files of all parts and moulds from CAD System
- Import these files in BlowView
- Convert these files into .pat (Patran) format in BlowView
- Meshing must be in triangular element format



Amira (.am), Ansys (.ans, cdv), AutoCAD (.dfx), Unigraphics (.inp), Catia (.stl), Proengineer (.stl), Ideas (.unv)

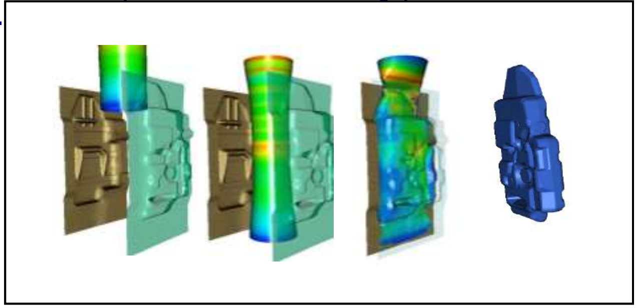
Mesh of Mould



Demo

Benefits from Simulation

- Conception and fabrication of a mould & part adapted to the client's need and to the market. The manufactures will have to produce more and more complex parts with specific characteristics. The simulation will allow customers to quickly make those parts.
- Guide in the design of moulds by identifying troubled area and minimize design problem before production. Help diagnostic various manufacturing defects (warping, webs and folds). These problems can be avoided right away in the simulation stage.
- Guide the choice of equipment to produce new parts. A part can be simulated with different types of die in order to find the optimal way to produce it.
- Reduction in the product development cycle. By using process simulation, the customer can proceed to modifications and improvements at the design time and develop a better part faster by identifying problems earlier on. It can avoid costly trial and error in the mould fabrication stage.
- Help in diagnostic various manufacturing defects (warping, webs and folds) to improve the part quality. These problems can be avoided right away in the simulation stage.
- Eliminate trial and error method by simulating those different possibility virtually , reduce the development costs. By reducing the number of trials and error, thus reducing the number of prototype, the customer can reduce its cost of mold rework, material and labor.
- Production processes optimization. The optimization module allows the customer to optimize the existing process to find the optimal processing conditions of the machine for the desired parts.



Questions?

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