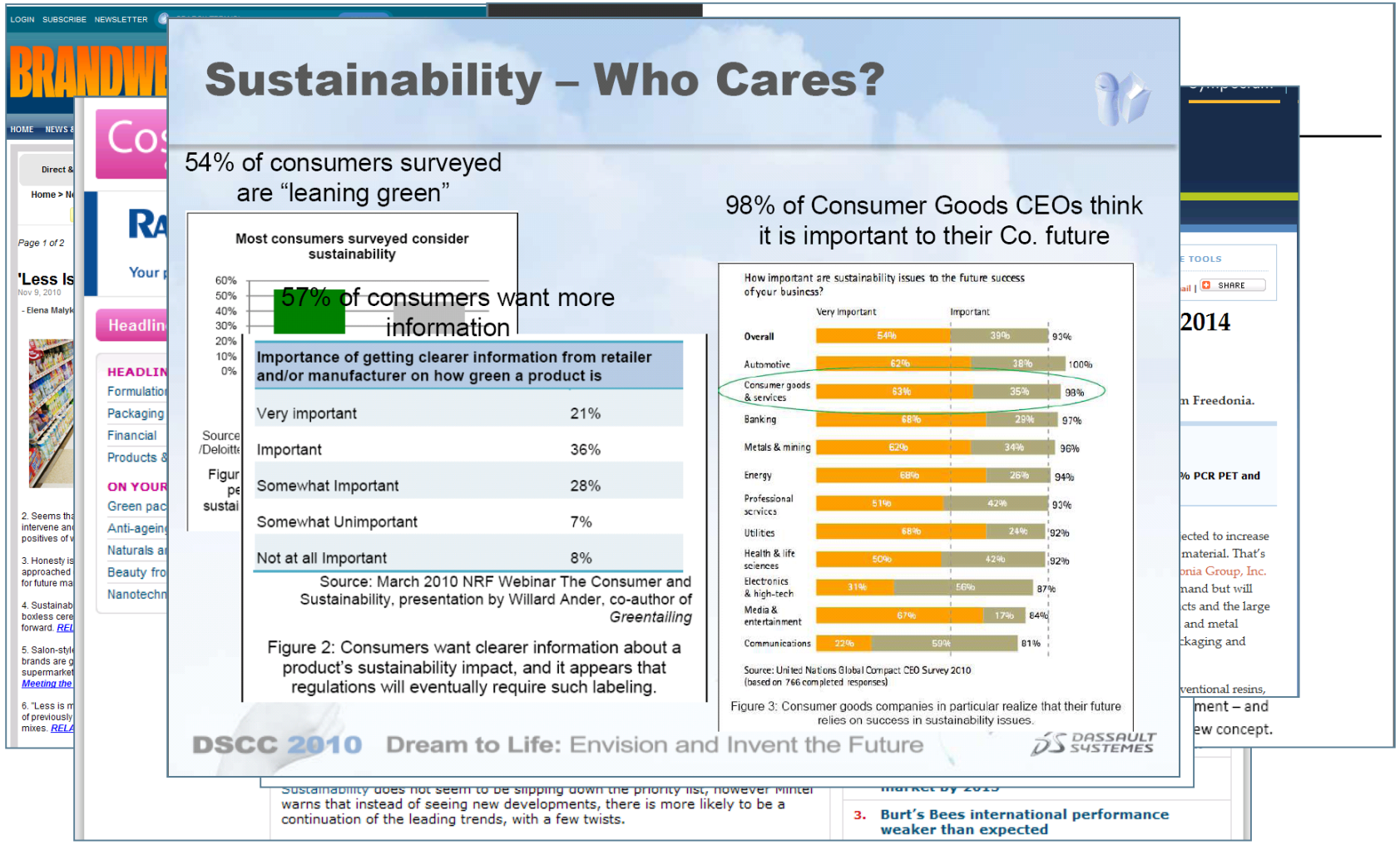
simuleon

SIMULIA for Consumer Packaged Goods

David Cadge, Industry Lead – Consumer Packaged Goods

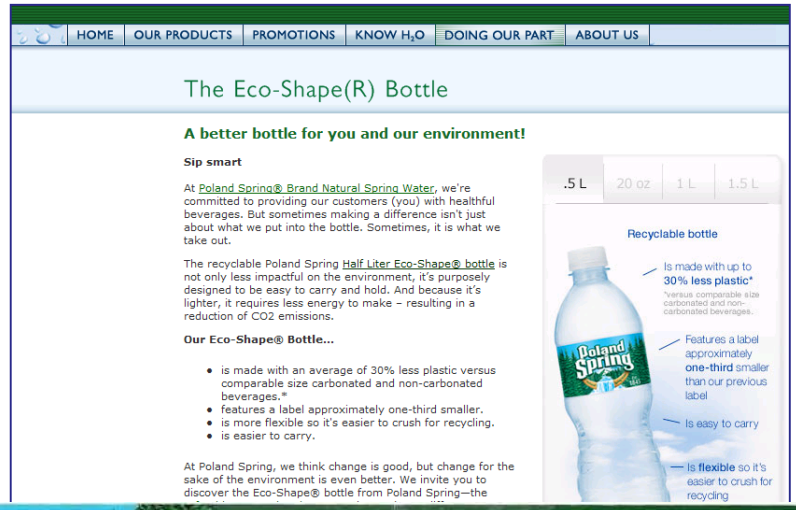
CPG Design Issues

#1 Sustainability



How Simulation Drives Sustainable Design

- Simulation enables Designers to investigate:
  - Material reduction – Lightweighting
  - Material replacement – Recycled materials
  - Package design alternatives
  - Process optimization



Lightweighting

- Reducing the amount of material to save: Weight, Money, the Planet
  - Real-world workflow combining CATIA, Abaqus, Isight, and SLM (SCE and SEE) to showcase the full strength of our solution

Lightweighting Customer Reference

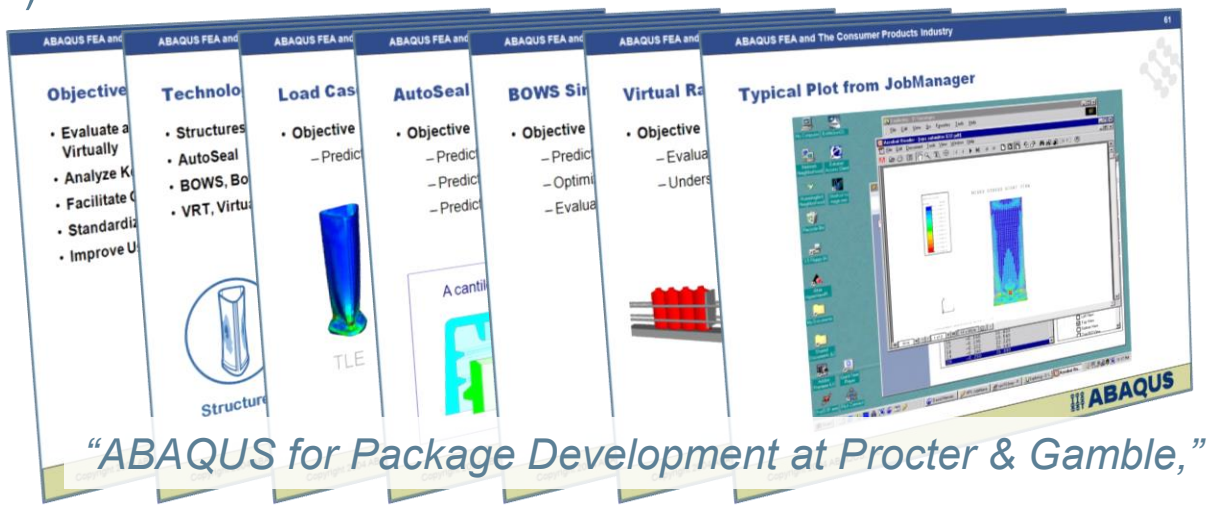
INSIGHTS May-2010, "Lighten up! Amcor Uses Realistic Simulation to Stay on Top in Plastic Container Market"

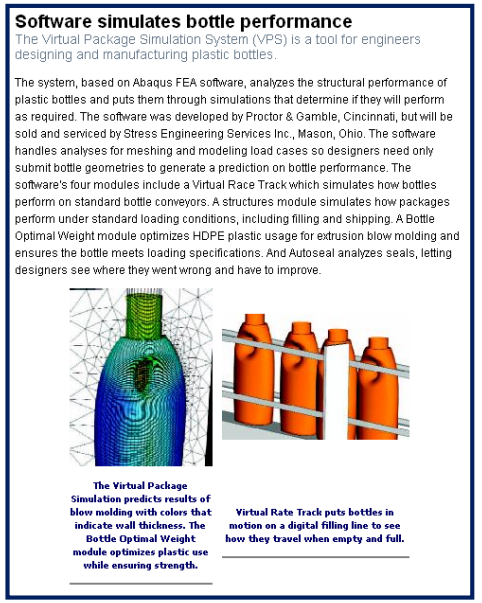
"A container made with too much, or too little, material can be very expensive," says Amcor's Advanced Engineering Services group manager Suresh Krishnan. "Too little material can lead to containers failing, and too much can cost us a fortune. ***Lightweighting our products is one of the key things that has sustained Amcor against our competition during these tough times, and computer-aided engineering, within a PLM environment, has been critical to achieving that."***

CPG Design Issues

#2 Capturing advanced simulation for use by non-experts

- P&G do this through their Virtual Packaging Simulation System
  - Structural loading
  - Sealing
  - Blow molding (BOWS)
  - Conveying (VRT)





Software simulates bottle performance

The Virtual Package Simulation System (VPS) is a tool for engineers designing and manufacturing plastic bottles.

The system, based on Abaqus FEA software, analyzes the structural performance of plastic bottles and puts them through simulations that determine if they will perform as required. The software was developed by Proctor & Gamble, Cincinnati, but will be sold and serviced by Stress Engineering Services Inc., Mason, Ohio. The software handles analyses for meshing and modeling load cases so designers need only submit bottle geometries to generate a prediction on bottle performance. The software's four modules include a Virtual Race Track which simulates how bottles perform on standard bottle conveyors. A structures module simulates how packages perform under standard loading conditions, including filling and shipping. A Bottle Optimal Weight module optimizes HDPE plastic usage for extrusion blow molding and ensures the bottle meets loading specifications. And Autoseal analyzes seals, letting designers see where they went wrong and have to improve.

The Virtual Package Simulation predicts results of blow molding with colors that indicate wall thickness. The Bottle Optimal Weight module optimizes plastic use while ensuring strength.

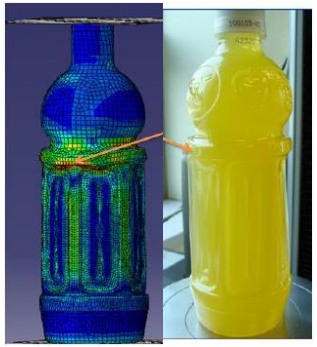
Virtual Rate Track puts bottles in motion on a digital filling line to see how they travel when empty and full.

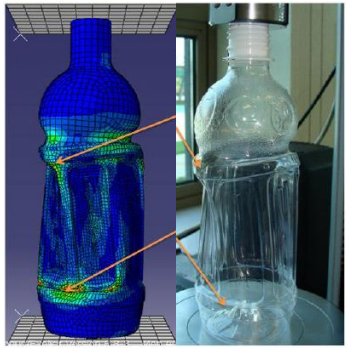
"ABAQUS for Package Development at Procter & Gamble," P&G – AUC 2002

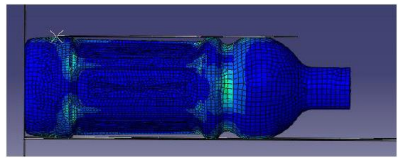
CPG Design Issues

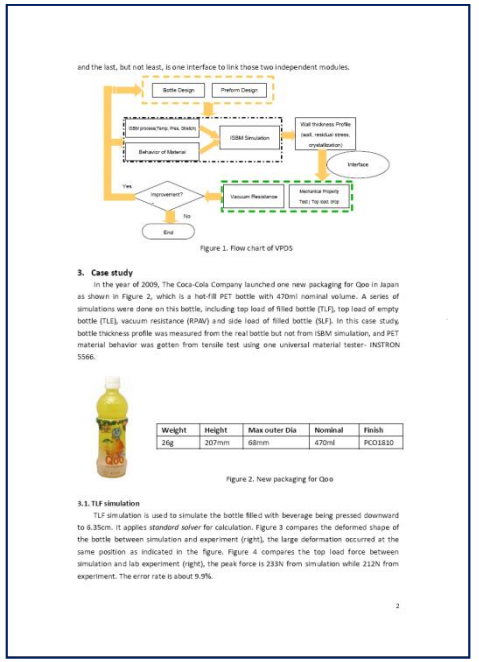
#2 Capturing advanced simulation for use by non-experts

- Coca-Cola have developed a Virtual Packaging System (VPS)









and the last, but not least, is one interface to link those two independent modules.

Figure 1. Flow chart of VPOS

3. Case study

In the year of 2009, The Coca-Cola Company launched one new packaging for Qoo in Japan as shown in Figure 2, which is a hot-fill PET bottle with 470ml nominal volume. A series of simulations were done on this bottle, including top load of filled bottle (TLF), top load of empty bottle (TLE), vacuum resistance (RPAV) and side load of filled bottle (SLF). In this case study, bottle thickness profile was measured from the real bottle but not from ISBM simulation, and PET material behavior was gotten from tensile test using one universal material tester- INSTRON 5566.

Weight	Height	Max outer Dia	Nominal	Finish
26g	207mm	68mm	470ml	PCO1810

Figure 2. New packaging for Qoo

3.1. TLF simulation

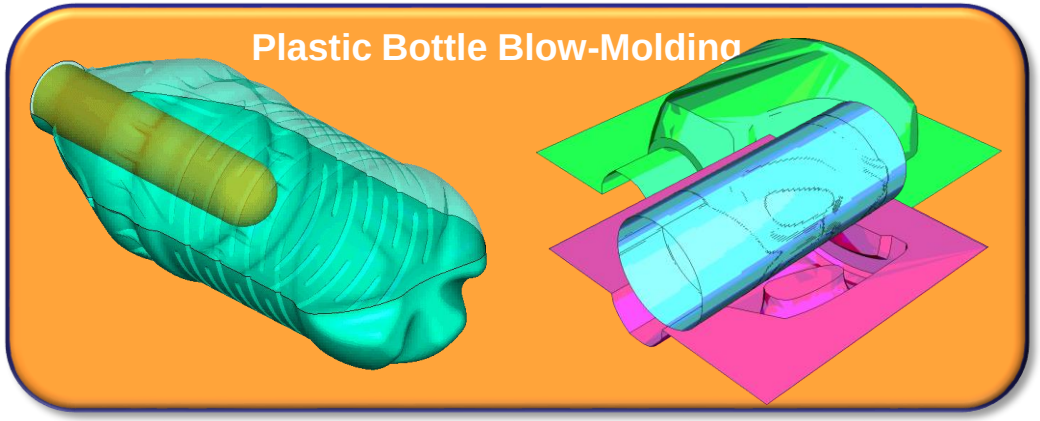
TLF simulation is used to simulate the bottle filled with beverage being pressed downward to 6.35cm. It applies *standard solver* for calculation. Figure 3 compares the deformed shape of the bottle between simulation and experiment (right), the large deformation occurred at the same position as indicated in the figure. Figure 4 compares the top load force between simulation and lab experiment (right), the peak force is 233N from simulation while 212N from experiment. The error rate is about 9.9%.

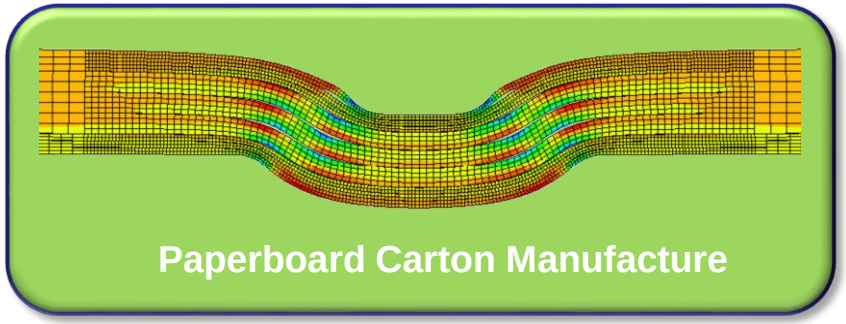
2

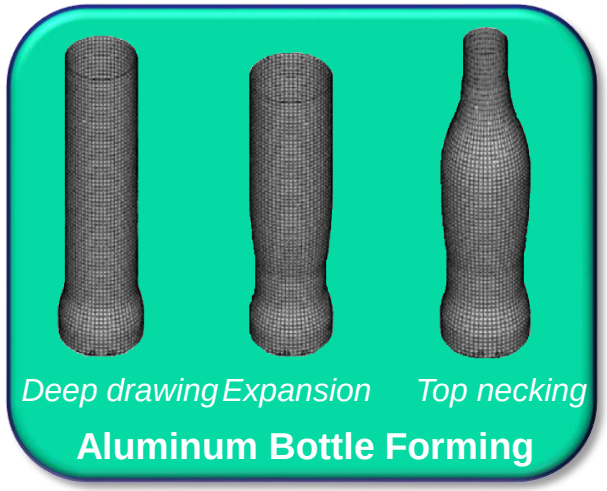
"Evaluation of Beverage Packaging Designs Using Abaqus,"
Coca-Cola Beverage – SIMULIA-China RUM-2010

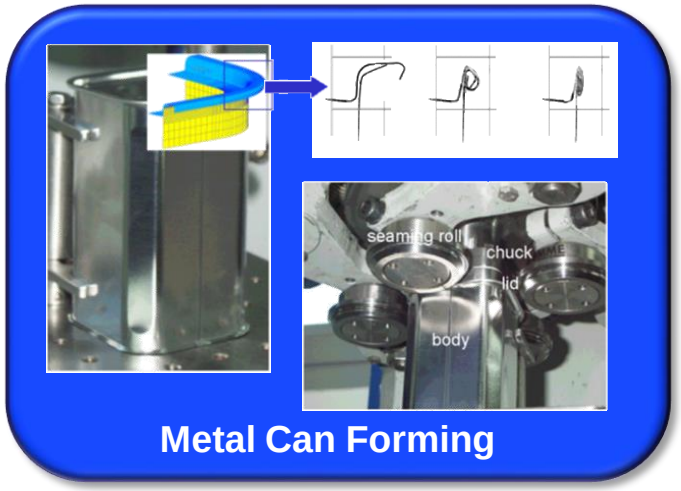
VPS BASED ON ABAQUS CAN EVALUATE DESIGN ALTERNATIVES QUICKLY AND SHORTEN TIME TO MARKET, REDUCING EXPENSIVE TRIAL-AND-ERROR

Package Manufacturing

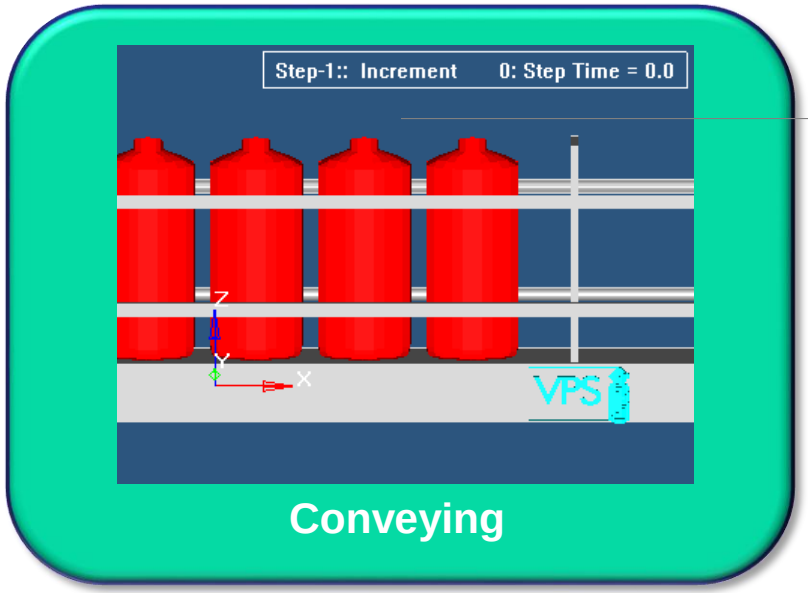


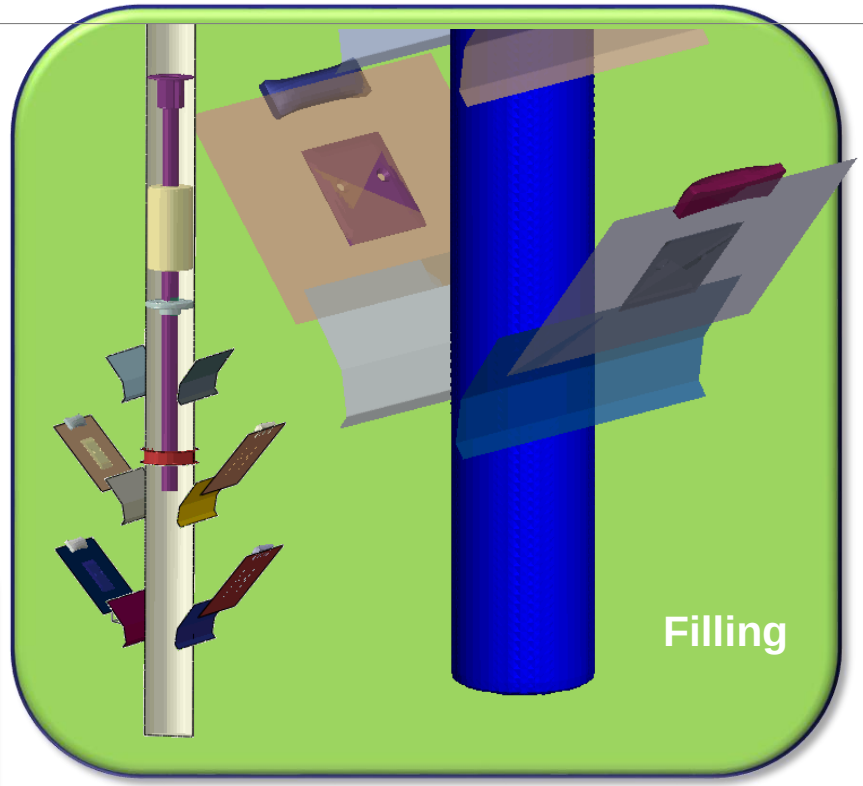




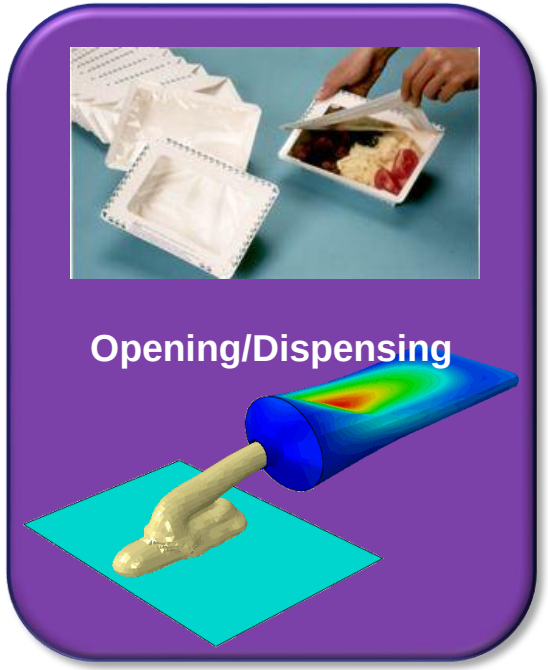


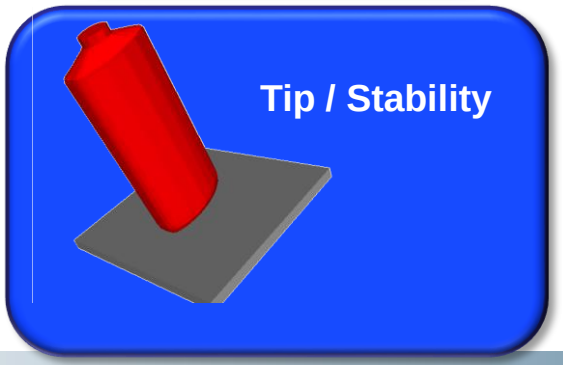
Package Processing

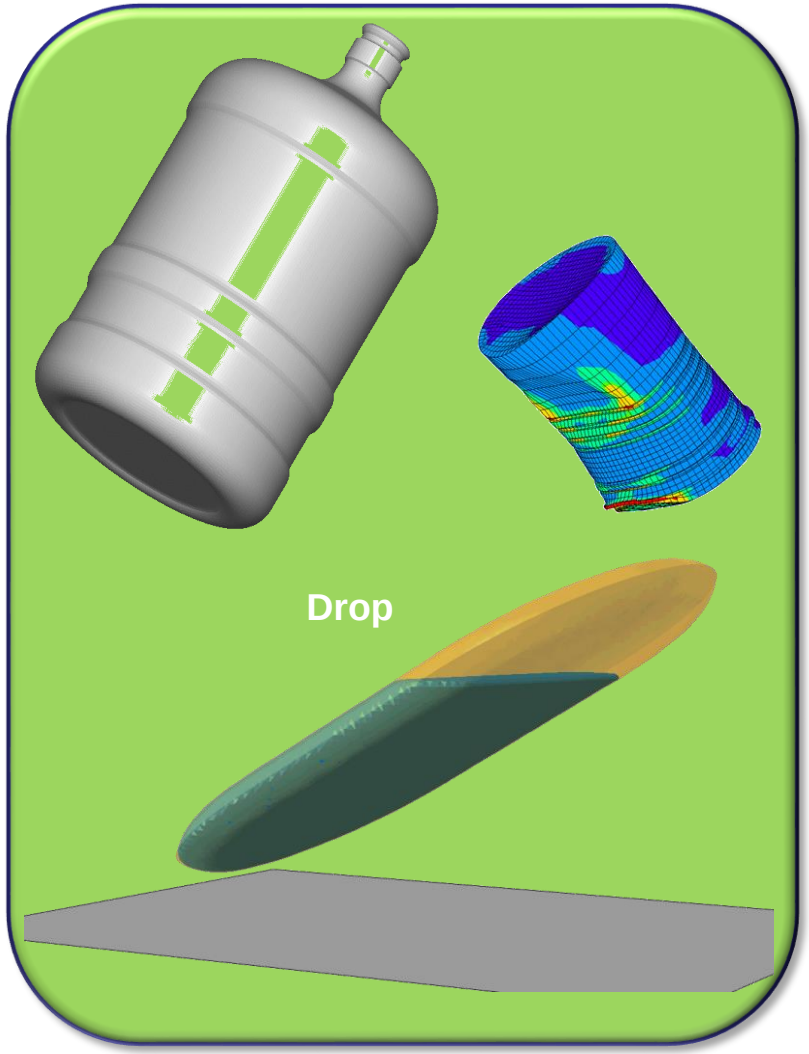




Package Performance





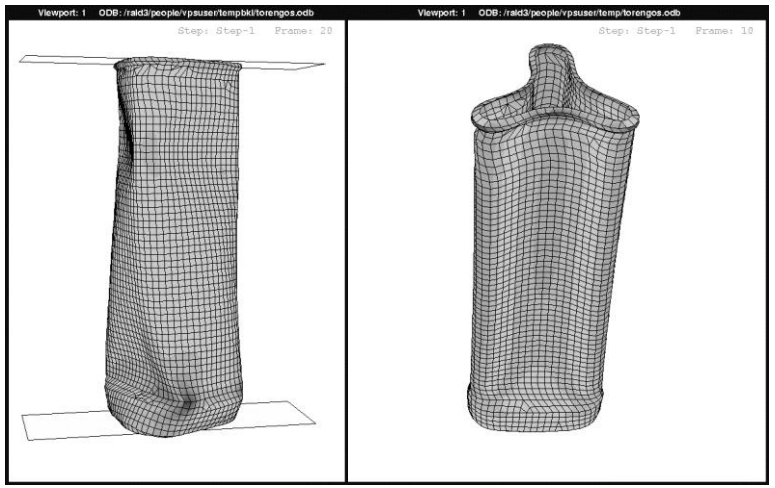


Procter & Gamble

"ABAQUS for Package Development at Procter & Gamble," AUC-2002

Abaqus for Package Development

"ABAQUS was first used at P&G in 1985…. Now ABAQUS is widely used in P&G around the globe. P&G has embraced the technology and sees its strategic importance for achieving better solutions and ultimately better products for the consumer in less time."



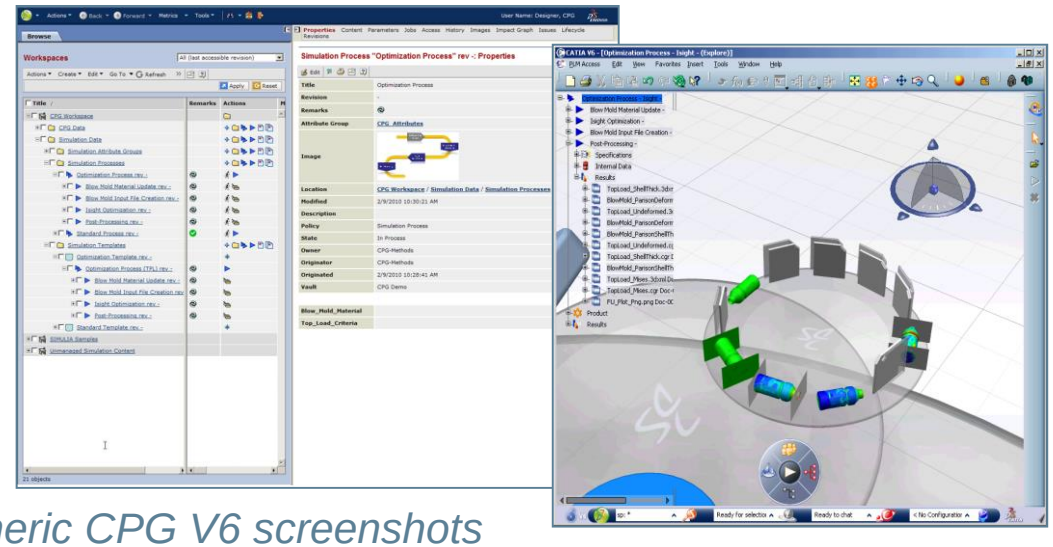
Top Load Empty and Vacuum load case results for Torengos

ACHIEVING BETTER SOLUTIONS AND BETTER PRODUCTS IN LESS TIME

Procter & Gamble

Procter & Gamble Selects Dassault Systèmes as Enterprise Simulation Partner

"It is our goal to make the benefits of realistic simulation available to a broader range of users than previously possible. SIMULIA SLM will help our global teams accelerate innovation by providing access to simulation tools, validated processes and corporate knowledge bases throughout the product lifecycle."



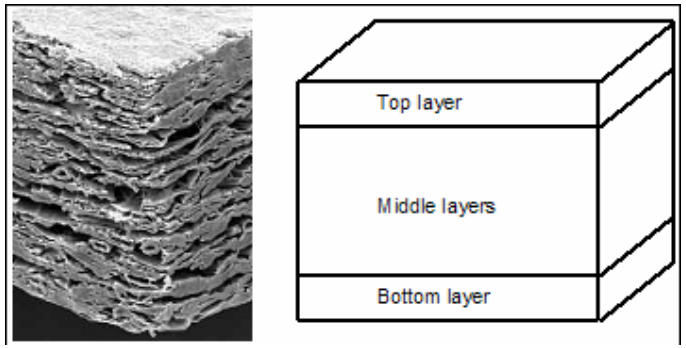
Generic CPG V6 screenshots

SIMULIA SLM WILL HELP OUR GLOBAL TEAMS ACCELERATE INNOVATION

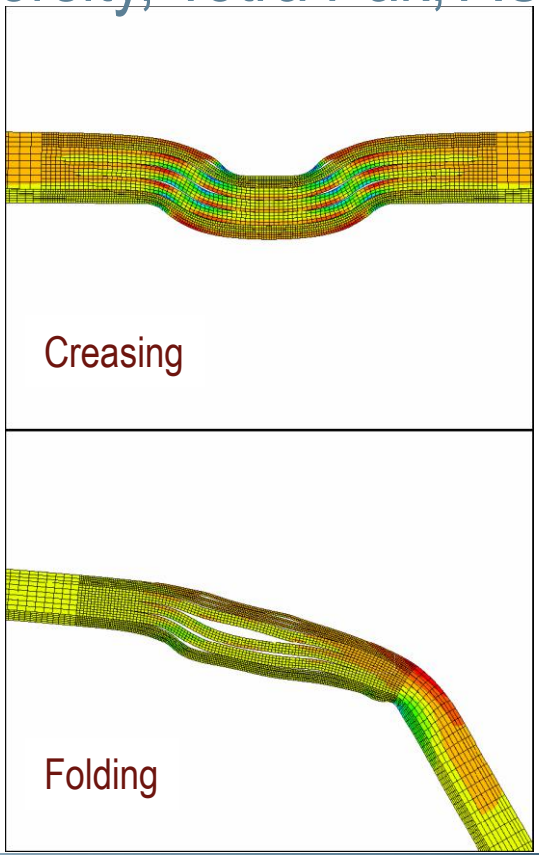
Tetra Pak

"A Finite Element Model For Simulations Of Creasing And Folding Of Paperboard," STFI-Packforsk, Karlstad University, Tetra Pak, AUC 2005

- Paperboard Carton Manufacture



Paperboard structure

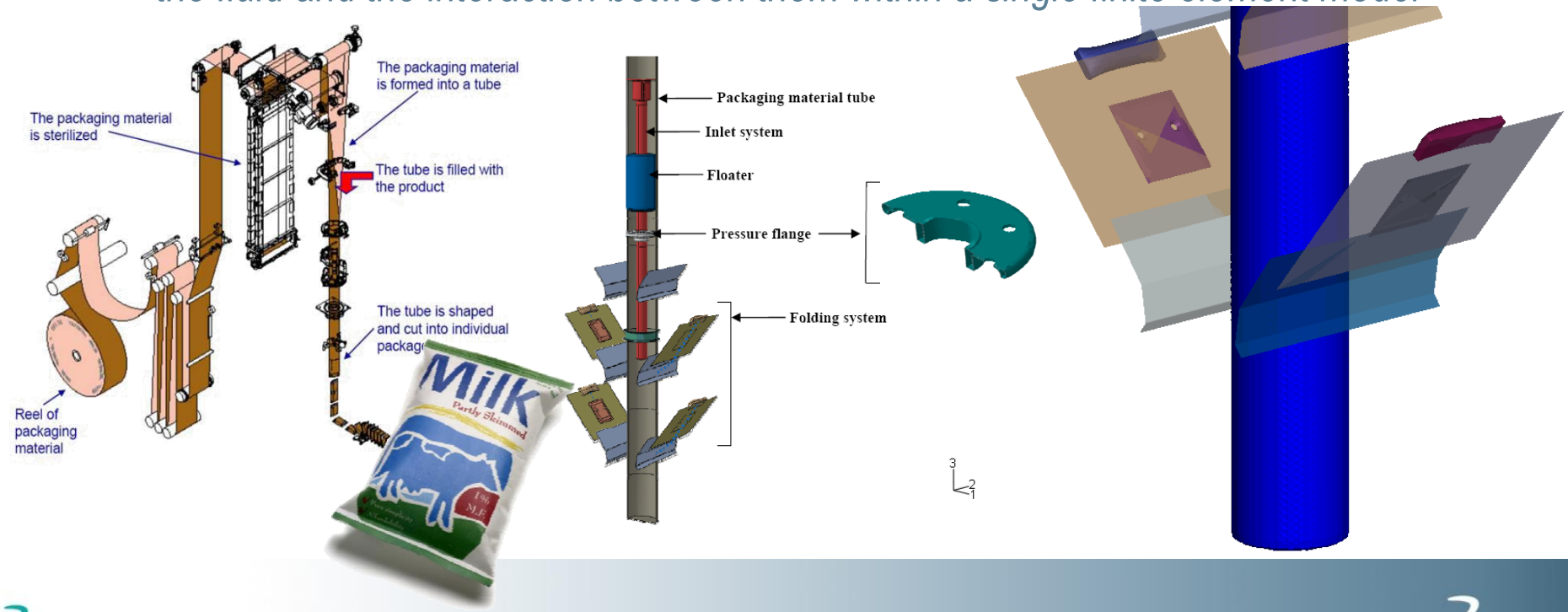


Tetra Pak

“Simulation of the Forming Process of Liquid Filled Packages Using CEL” SCC 2009

Package Filling

“CEL simulates the deformation of the packaging material,
the fluid and the interaction between them within a single finite element model”



Tetra Pak

INSIGHTS Jan-2011, “Packaged for Freshness with Realistic Simulation”

CUSTOMER SPOTLIGHT

Packaged for Freshness with Realistic Simulation

Simulation of material and fluids with Abaqus FEA helps decrease development time while improving quality of innovative aseptic packaging

At the turn of this century, many experts compiled “Top-ten” lists for the greatest record-setting athletic performances, the best all-time songs, the top news stories, and many other social achievements of the previous hundred years. The Number One food science innovation of the twentieth century selected by the Institute of Food Technologists — ahead of even concentrated juices, safe canning, and freeze drying — was aseptic processing and packaging.

Aseptic processing dates from the early 1960s. It involves ultra-high-temperature (UHT) treatment of milk and other liquid foods for a few seconds in order to remove all harmful micro-organisms while preserving nutrients and flavor compounds better than traditional pasteurization and canning done at lower temperatures for longer times. The result is that UHT food products remain fresh for months during shipping or storage without requiring refrigeration or preservatives. This provides significant cost savings to everyone—from the producer to the consumer—as well as long-life, healthy nourishment in developing countries lacking adequate power grids, cold chains or transportation infrastructure.

Tetra Pak is the world’s largest supplier of aseptic packaging. Its founder, Dr. Ruben Rausing, began the company in Lund, Sweden in 1951 with a simple tenet: “A package should save more than it costs.” Rausing invented the packaging technology that still forms the basis for much of Tetra Pak’s business. Currently the company distributes more than 387 million packages per day in over 150 countries, for a total of more than 141 billion delivered worldwide in 2008.

As the company is committed to providing the lowest-cost packages possible, every new product line presents a challenge: is the thin, lightweight material strong enough to withstand the filling and sealing process? “Complete control over the process is paramount,” says Dr. Marcus Olsson, Manager, Virtual Engineering at Tetra Pak. “That requires an in-depth knowledge of the loads and forces involved—both liquid and material.”

Cartons, Fluids, and Forces

Both for cost and for control, the packaging process is designed to be as simple as possible. But keeping it simple poses tremendous engineering challenges. A continuous reel of carton-based packing material—a composite of mostly paper, with some ultra thin layers of plastic and aluminum—is fed into the top of a filling machine and sterilized along the way. The flat packaging material is formed into a tube and sealed longitudinally. A pipe from the filling machine enters the top of this packing material tube, filling it with liquid and causing it to expand. A mechanical system folds and transversely seals the package, below the surface of the fluid, keeping it sterile while forming it into the desired shape. The tube is then cut into individual packages.

Schematic of a filling and packaging system for an aseptic liquid container.

Even though the process is simple, the forces at play are not. “Gravity is driving the liquid down,” Olsson says, “but the folding and the tube deformations are forcing it backward”—much like the action of getting a kink in a garden hose. A pressure flange (essentially a flat disk with small holes in it) mounted inside the tube, above the folding system, reduces the amount of backflow up the tube. But the packaging tube is subject to deformation under folding and considerable changes in fluid pressure, and it needs to retain its structural integrity without breaking or crimping.

“When designing new package shapes and sizes,” Olsson says, “or when modifying the filling machine—for instance by increasing the filling speed—the folding and forming of the package are critical. In the past, these have been difficult to predict.” Customarily, the packaging and filling process was verified by physical testing on a nearly finalized machine. But if the test revealed design problems at that stage, it was more expensive to introduce changes than it would have been earlier in product development. “What we needed,” Olsson points out, “was a realistic, reliable simulation method that took into account the liquid, the packaging material, and all the major forces acting—and interacting—on them.”

So Tetra Pak selected Abaqus finite element analysis software from SIMULIA, the Dassault Systèmes brand for realistic simulation, to evaluate the complexities of its packaging process. The company had previously used Abaqus for structural analyses, but this was the first time that Tetra Pak engineers simulated the dynamics of the fluid-structure interaction during packaging. The resulting analysis generated a greater understanding of the packaging process and provided a means to model it earlier in the design stage. “We anticipate that use of simulation will help save us a significant amount of product development time,” says Olsson.

A Model Packaging Process

For their initial trial analysis, the engineers selected the Tetra Fino Aseptic 500 ml. This 500ml milk package—the mid-range size of an extremely low-cost and high-volume product line. “We already had a strong knowledge of production parameters for this application,” Olsson says, “so it made an excellent choice for our initial analysis.” Dr. Anders Magnusson, Technology Specialist at Tetra Pak, worked with Olsson on the simulation.

There were a number of challenges to modeling the process. The packaging material was very thin and flexible, which made for large deformations under pressure changes. The cross-section of the tube rapidly changed from circular cross-section to fully closed when folded. Most important, there was a strong fluid-structure interaction to be modeled that had to take into account the changing pressure waves in the fluid and their effects on the packaging material.

The model for analysis included the following components:

- The composite packaging material (a paper, aluminum and plastic carton tube, modeled as a homogenous material)
- The packaged fluid, including its flow and pressure properties
- The flotation device that rests on top of the fluid surface
- The system that folds the packaging material
- The pressure flange that controls (dampens) pressure waves inside the tube

With the exception of the deformable packaging-material tube and the liquid, the components were modeled as rigid bodies. These structural items were modeled in a Lagrangian framework, which is a commonly used method of simplifying the application of forces to objects and quantifying their reactions.

The flexible packaging material was modeled with shell elements calibrated to represent the laminated material as though it were homogenous, which reduced the computation time for the analysis.

The fluid was modeled using an Eulerian approach that captures the characteristics of non-viscous fluid flow. By coupling this with the Lagrangian approach, Tetra Pak’s engineers could now model the interaction of the packaging tube and the fluid in one analysis. “The Coupled Eulerian-Lagrangian capability in Abaqus allowed us to include effects from the packaging dynamics—tube deformations under flow and pressure changes—that we had never simulated in a single model before,” Magnusson says. Abaqus’ strong contact and nonlinear capabilities were also essential to the analysis.

Because the packaging process is axially symmetric, the engineers were able to model one-half of the system to substantially reduce processing time. The model involved roughly 220,000 elements, with approximately 700,000 variables. The analysis ran on a Linux 86-64 platform with an Intel Xeon Dual core processor, with the runs taking about 24 hours on 8 to16 processors.

Once the Coupled Eulerian-Lagrangian approach enabled the simulation to capture the deformation of the packaging material, the behavior of the fluid and the interaction between them entirely within a single FEA model, the engineers were able to model and define a variety of design parameters:

- Sequencing the folding system action, including the deformation of the material
- Determining the choice and suitability of the packaging material
- Establishing the correlation between fluid injection rate and formed packaging volume
- Defining the tensile load applied to the material so as to prevent breakage or crimping

“We were trying to model all the aspects of packaging that we had tested in physical prototyping,” Magnusson says. “In the end, we were able to simulate all the important forces of the process, from flow under gravity and pressure changes in the liquid, to deformation in the material.”

The Results—Good to Go

The FEA analysis realistically captured the packaging process, right down to arriving at the desired final shape of the filled and sealed package. It also demonstrated that including the interaction of the fluid and the packaging material in the simulation is imperative in order to calculate the degree of package deformation during filling and sealing. The simulation showed the need and effectiveness of the pressure flange device to control the gross bulk motion of the fluid, reducing the dynamic interaction between the fluid and the tube of packaging material. “Originally it was believed that modeling the role of the pressure flange would be difficult using the Coupled Eulerian-Lagrangian method, since physical tests had demonstrated turbulence effects,” Olsson observes. “But our analyses, with and without the flange, proved that this method could capture the fluid behavior well.” The next step is to verify the results with physical testing.

Half symmetry model of the structural components of packaging system.

Deformation of the packaging tube as the packaging seals.

In the long run, the Abaqus simulation will aid Tetra Pak as it develops new packages and upgrades existing machines. Using simulation early in design is expected to decrease the development time of the packaging processes while increasing package quality—an important goal for a packaging company whose motto is “Protects What’s Good,” and that strives to provide healthy and nutritious food throughout the world.

“Tetra Pak’s vision is that we commit to making food safe and available everywhere,” says Olsson. “The FEA analysis is a part of that vision, and it has significantly strengthened our understanding and knowledge of the physics at play in our packaging systems. SIMULIA will be important to our process development method going forward.”

For More Information
www.tetrapak.com
www.simulia.com/user_ref

INSIGHTS January/February 2010 11

www.simulia.com

10 INSIGHTS January/February 2010

Tetra Pak

“Origami with Abaqus,” SCC-2010

Paperboard Carton Manufacture

“Tetra Pak successfully use advanced simulations, customizations and optimizations techniques as integral part of the design process of the forming units for our filling machines.

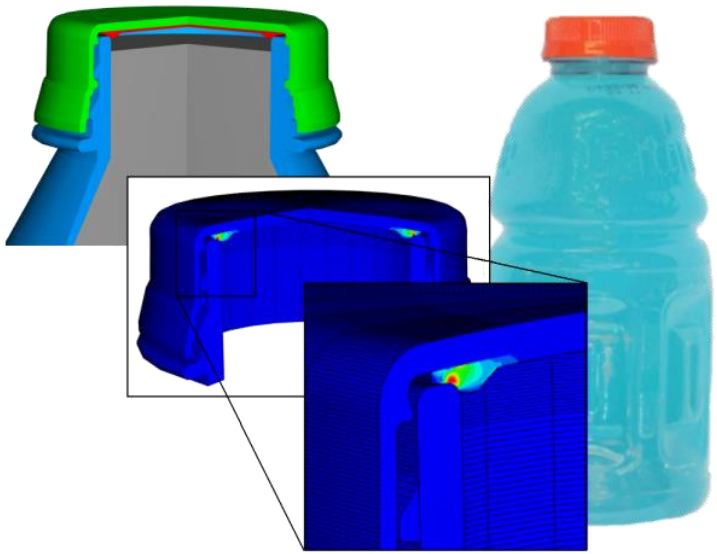
The use of these techniques allows us to optimize the forming process, to reduce the design time, to have more control on the entire process improving the quality of the final products.”

Alcoa

Closure System Bottle Cap Redesign

" SIMULIA engineers' expertise saved months of expensive, time consuming empirical testing. Abaqus FEA computer-aided design process reduced our typical redesign cycle by 50 percent or more!"

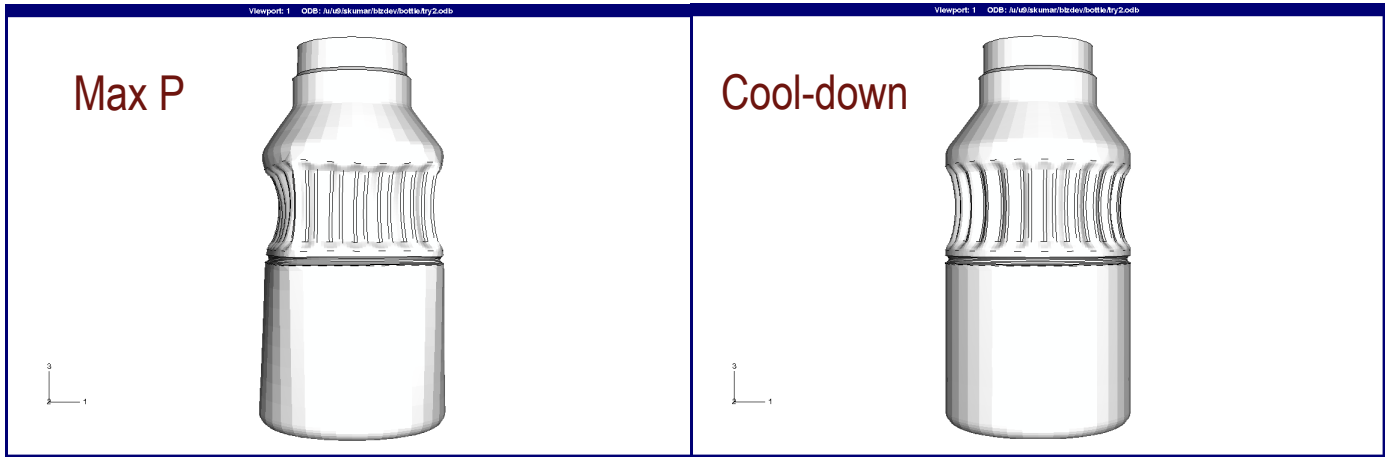
- Objective
  - Predict sealing performance
  - Predict over stressing of the parts
  - Predict torque requirements



50% REDUCTION IN REDESIGN CYCLE

Retort of Sealed Bottles during Sterilization

- Sealed plastic bottles soften and swell during retort
- Internal pressure depends on deformed shape, temperature, vapor pressure of contents, and headspace
- Design objective:
  - Design a container shape that minimizes material and performs well during retort

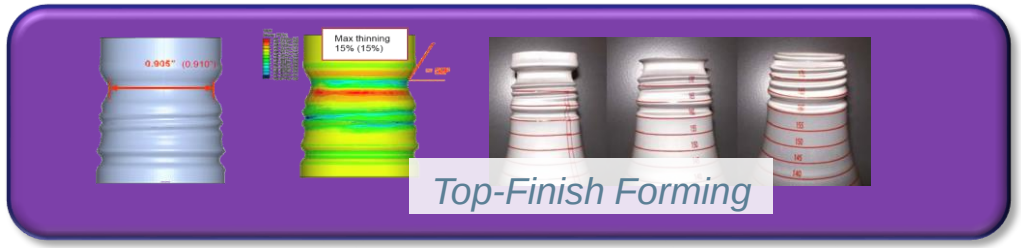


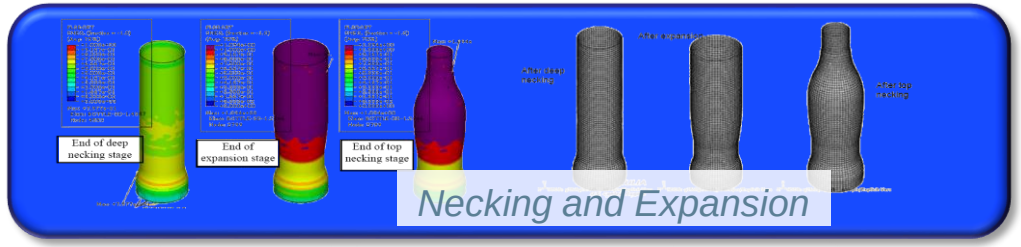
The Coca-Cola Company

“Aluminum Bottle Forming Simulation with Abaqus,” SCC2009

Aluminum Bottle Forming Simulation with Abaqus

“Solutions developed through Abaqus/Explicit simulations were implemented on a bottle pilot production line, resulting in the reduction of the package’s development time of about 75 percent, combined with a 50 percent reduction in cost.”



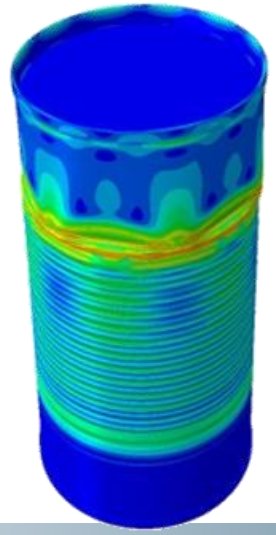


75% REDUCTION IN PACKAGE DEVELOPMENT TIME
50% REDUCTION IN COST

Silgan Containers

INSIGHTS May-2009, "Silgan Containers Uses State-of-the-Art Simulation Software to Increase Speed-to-Market by Predicting Can Performance"

"Silgan is using Abaqus to evaluate the physical behavior of its design concepts. As a result, Silgan is able to remove as much as three- to six-months from the design phase and thousands of dollars in tooling costs."

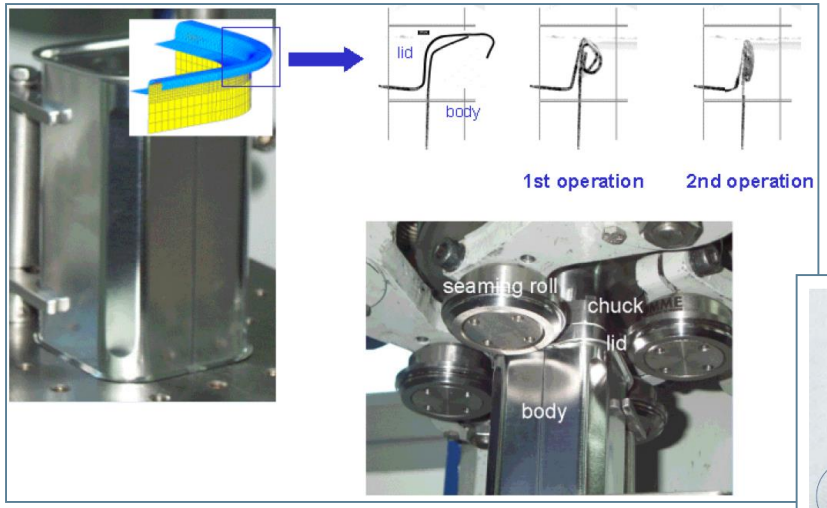


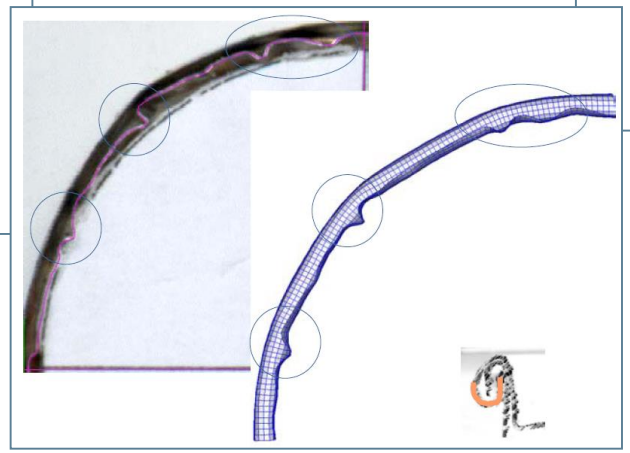
REMOVE THREE- TO SIX-MONTHS FROM THE DESIGN PHASE AND THOUSANDS OF DOLLARS IN TOOLING COSTS

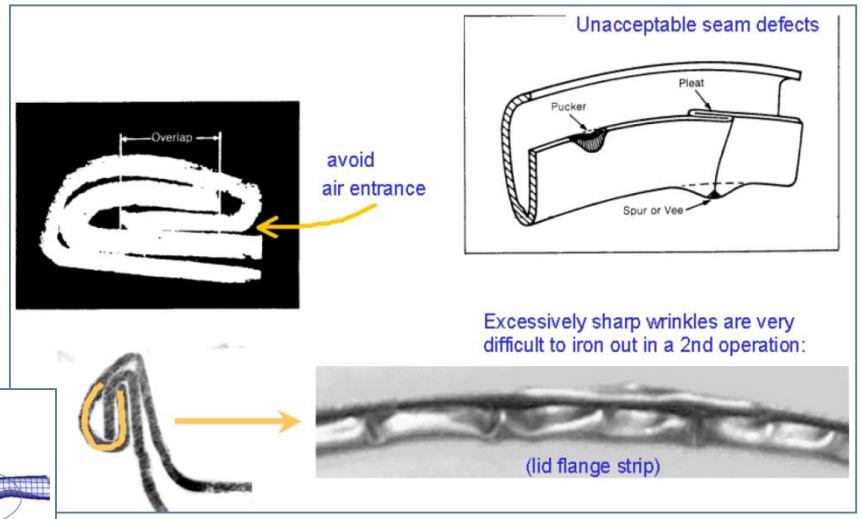
Corus

“Using Abaqus/Explicit In The Development of a New Can Concept,” AUC 2001

- Metal Can Forming





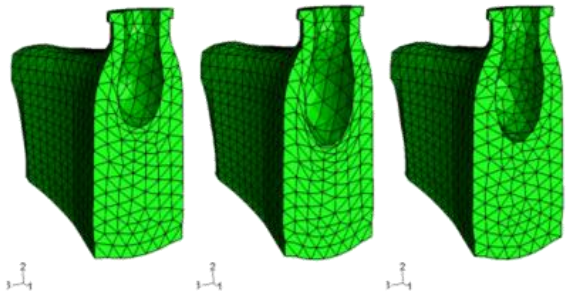


Glass Service Improve BV

"Advanced Simulation of 3D Glass Bottle Forming," AUC 2007

Reduced Time and Cost of Bottle Blow Molding with Realistic Simulation Solutions from Dassault Systèmes

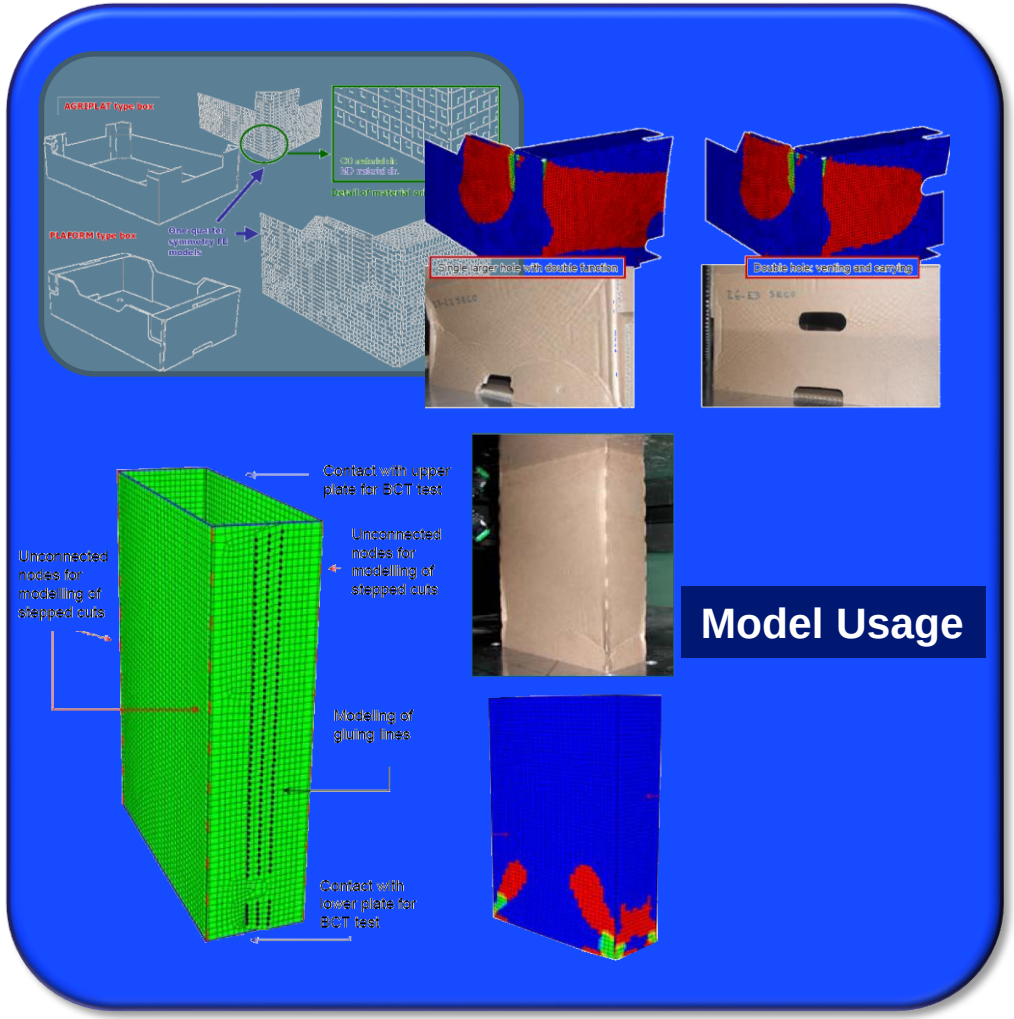
"SIMULIA's expertise and Abaqus FEA software make it possible for our customers, such as Bormioli Luigi, to save money and shorten time to market for boutique glass designs like perfume bottles."

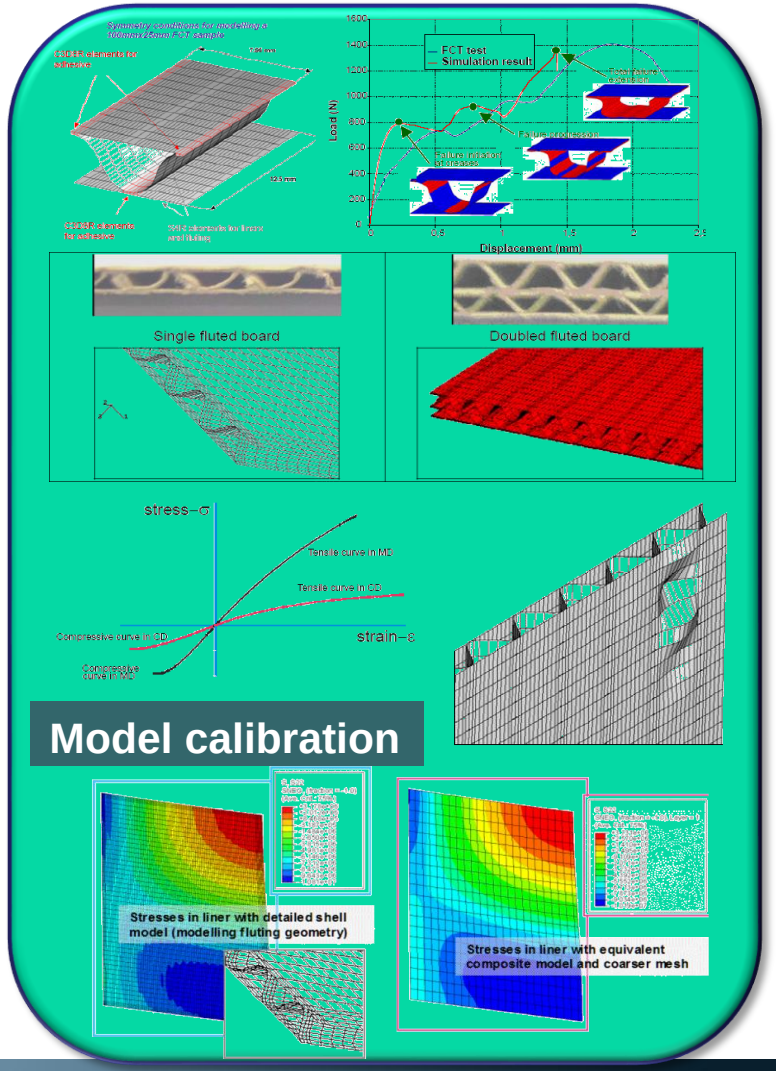


SAVE MONEY AND SHORTEN TIME TO MARKET

Instituto Tecnológico de Aragón

"Design of Different Types of Corrugated Board Packages Using Finite Element Tools," SCC 2009





Data And IP Management

SIMULIA Realistic Simulation News Jan-2011, “Simulation Lifecycle Management Solves the Hard Challenges of “Soft” Products”


Customer Viewpoint

Simulation Lifecycle Management Solves the Hard Challenges of “Soft” Products

Chris Pieper, Associate Research Fellow, Kimberly-Clark Corp.

CPG Strategy

INSIGHTS May-2009 “Strategy for Sustainable Innovation in Consumer Packaged Goods”

- SIMULIA is executing on a multi-year simulation strategy for CPG

Why DS and SIMULIA for CPG?

Complete Solution

- Realistic simulation with Abaqus technology
- Process Integration and Optimization with Isight
- IP management with SLM
- Simulation for designers with DesignSight

Long-term commitment to industry success

V6 Collaboration Environment

- Strategic collaborations with key customers
- Continued improvements to all product lines – Abaqus, Isight, SLM, DesignSight etc.

SIMULIA for Consumer Packaged Goods