

ANSYS POLYFLOW

Powerful Fluid Dynamics Software for Parts Manufacturing Processes

For the last quarter-century, ANSYS® POLYFLOW® software has been the flow analysis code of choice of leading manufacturing companies in the polymer, glass, metals and cement processing industries. The technology is used extensively to design and optimize processes such as extrusion, thermoforming, blow molding, glass forming, fiber drawing and concrete shaping. Recognition of the value of ANSYS POLYFLOW is due to a unique combination of capabilities:

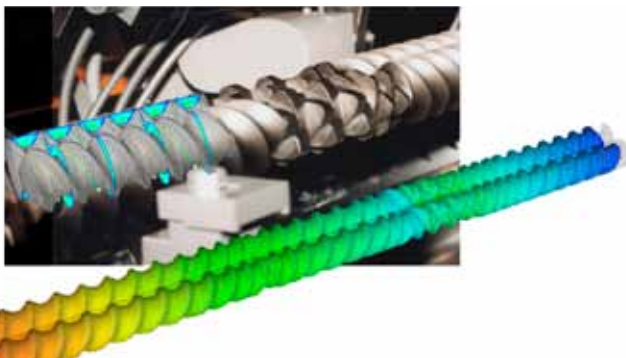
- Advanced material rheology models, including viscoelasticity
- Deforming mesh, free surface tracking, contact detection and mesh superposition technique
- Reverse engineering methods such as inverse die design and parison programming
- Finely tuned solver numerics and post-processing

Design engineers regularly choose ANSYS POLYFLOW software to minimize physical prototyping when manufacturing an extrusion die or reducing thickness variation to improve the quality of thermoformed or blown products. Customers report dramatic return on investment once they've introduced ANSYS POLYFLOW fluid dynamics modeling into their design processes.

ANSYS POLYFLOW and the ANSYS Workbench Environment

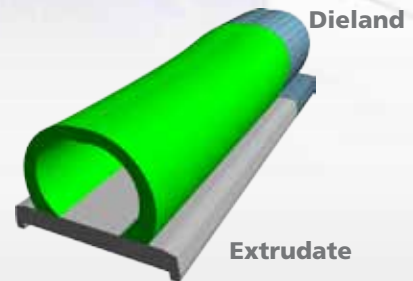
ANSYS POLYFLOW software is fully integrated into the ANSYS® Workbench™ environment, the framework for the full engineering simulation suite of solutions from ANSYS. Its adaptive architecture enables users to easily set up any problem from standard fluid flow analysis to complex interacting systems with simple drag-and-drop operations. Within ANSYS Workbench, applications from multiple simulation disciplines can access tools common to all, such as CAD connections, geometry and meshing tools. ANSYS CFD-Post software can be used to compare results and to perform final data analyses.

These capabilities allow opportunities for Simulation Driven Product Development™ (SDPD) to drive innovation, enabling users to perform virtual prototyping, process optimization and virtual part testing in a scalable and cost-effective manner.



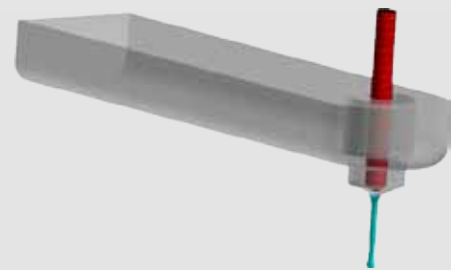
Application Solutions

Coextrusion Rubber Parts



Coextrusion of a soft (green) and dense (grey) rubber for automotive profile

Glass Gob Forming



3-D transient modeling of the fore-hearth and single gob forming process

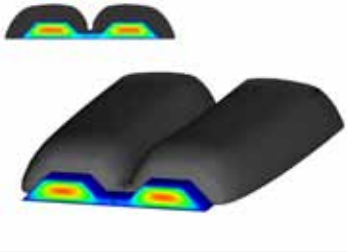
Extrusion Blow Molding



Parison programming and extrusion blow molding using shell elements forming process

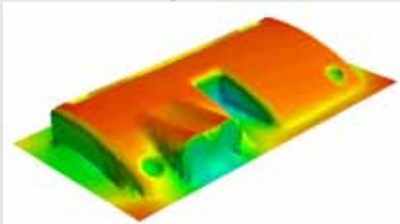
Application Solutions

Extrusion Blow Molding



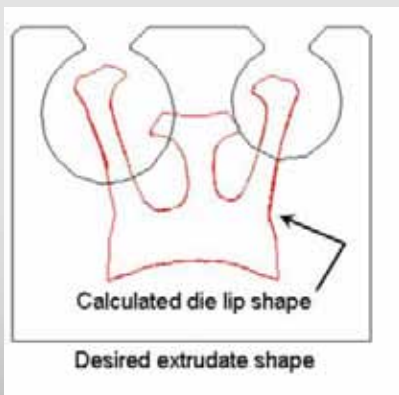
Velocity distribution in the die land and large die swell induced by stress relaxation

Thermoforming



Thickness distribution in a thermoformed dashboard; small thickness (blue) is seen as potential weakness

Profile Extrusion



Comparison between the desired profile (black) and the prescribed die lip automatically calculated by ANSYS POLYFLOW software (red) for a foamed extrudate profile

Solvers and Numerics

Industrial processes modeled by ANSYS POLYFLOW involve multiple nonlinearities and, thus, require a heavy-duty, efficient solver. Nonlinearities can stem either from complex rheological or thermal-dependent material behaviors or from large deformations (such as die swell, blow molding, thermoforming, glass pressing, etc.). ANSYS POLYFLOW software uses the finite element analysis (FEA) method, which is ideally suited for efficiently modeling flows of a complex rheological nature. It can easily accommodate deforming boundaries through its robust arbitrary Lagrangian-Eulerian (ALE) deforming-mesh capabilities. The software scales to solve advanced physical problems and simplifies the workflow for flows with complex geometries.

Advanced parallel processing numerics can efficiently utilize multiple multi-core processors in a shared memory machine. This reduces the turnaround time for results. ANSYS POLYFLOW software is available on Windows® and Linux® platforms.

Viscoelasticity and Complex Rheology

One of the key inputs to any successful numerical model is properly characterized material behavior. Flow characteristics of materials such as plastic, rubber, glass, metal, food substances and concrete are dependant on the material itself, of course, but they also are dependent on process properties such as shear rate, thermal and/or shear history. In addition to providing power law, Bird–Carreau, Cross, Herschel–Bulkley and other rheological models for common, generalized Newtonian laws, ANSYS POLYFLOW offers Giesekus–Leonov, PTT, pom–pom, simplified and other viscoelastic models. These models are used to accurately quantify large die swell encountered in some extrusion processes or extensional behavior typical in forming, film-casting and fiber-spinning applications.

Free Surface Modeling

Materials in extrusion, thermoforming, blow molding, film casting, glass pressing, blowing and other diverse applications undergo large deformations during processing. ANSYS POLYFLOW software consistently has been a leading technology for polymer processing and glass forming applications, with advanced algorithms that accurately predict deformation of material under processing conditions. Recent VOF free-surface modeling algorithms remove the limits of free surface complexity so they can be modeled in a time-efficient manner on a fixed mesh.

Inverse Problem: Profile Extrusion Die Design

Solving the inverse problem (identifying the operating conditions under which to consistently manufacture a high-quality product) has always been the primary goal for engineers. A large number of extrusion companies have successfully implemented the unique inverse die design capabilities of ANSYS POLYFLOW software. This feature automatically adjusts the die lip to achieve the desired product profile while taking into account the die swell and extrudate deformations. This unique technique can be used for numerous applications such as extrusion, coextrusion, fiber spinning and cable coating.

"With increasing worldwide competition, even small, local plastic parts manufacturers cannot disregard modern technologies, such as engineering simulation, to cut cost and time to market. By using ANSYS POLYFLOW, we have been able to help our customers meet their targets. Our ROI has increased several hundred percent since the year we first applied virtual prototyping."

*Philippe Kleim
CEO, Gamma Point*

Contact Detection

At some point during the forming process, products such as blow molded gas tanks, pressed glass or even rubber parts manufactured through compression molding involve contact between the tools and the materials. Blow molding, thermoforming, stamping, glass pressing and blowing are examples of just some of these manufacturing processes. To properly model any forming process, it is essential to accurately detect the contact between the deforming material and molds, stamps, plungers, knives and other tools as well as the changes in mechanical and thermal conditions before and after contact. ANSYS POLYFLOW combines advanced nonlinear contact detection with a robust, adaptive remeshing technique that automatically addresses the challenges caused by very large deformations and complex geometries. In addition, the mold motion can be calculated using either a specified force or a specified velocity.

Mesh Superposition Technique

Extruders, whether single-screw extruders (SSEs) or twin-screw extruders (TSEs), are geometrically complex devices in which the flow domain is continuously changing. The thermal and mechanical interactions with the barrel or the rotating screw(s) play a major role in achieving high-quality extrusions. For the ANSYS POLYFLOW tool, the company developed and validated the mesh superposition technique (MST), an innovative overlapping mesh approach that allows users to easily build a virtual extruder and model the fully filled section of the screw in a full 3-D environment. Dispersive and distributive mixing models together with particle tracking and statistical analysis provide the user with reliable tools to quantitatively compare different extruders and mixing devices.

Nonlinear Thermal Effects Including Radiation

Thermal effects play a major role in many processes. ANSYS POLYFLOW models include viscous heating that potentially leads to the deterioration of a polymer grade or undesired rubber curing. Accurate modeling of high-temperature processes such as glass forming necessitates nonlinear variation of the material properties and operating conditions, radiation (discrete ordinate model) and stress relaxation during the cooling process reproduced by the Narayanaswamy model.

Fluid Structure Interaction

Native fluid structure interaction (FSI) is available in ANSYS POLYFLOW software to model thermomechanical interactions between flowing materials and surrounding solids in a fully coupled approach. Large deformations within the elastic zone refine the virtual model to further improve the quality of the results. Seamlessly exporting ANSYS POLYFLOW results to ANSYS® Mechanical™ software for the purpose of performing structural analysis completes the virtual prototyping workflow, significantly reducing the time to market. The new ANSYS® LS-DYNA® output export can be used to perform virtual drop tests and to calculate top-loading deformation using explicit methods.

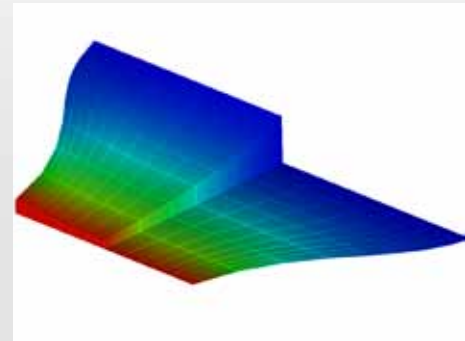
Application Solutions

Glass Float



Temperature distribution in glass float process; the thin sheet of glass is floated on a tin bath. Rolls convey and stretch the glass to get a uniform thickness

Film Casting



Velocity magnitude in the film: a membrane element is used for calculation (right side of picture) and post-processed in 3-D (left side)

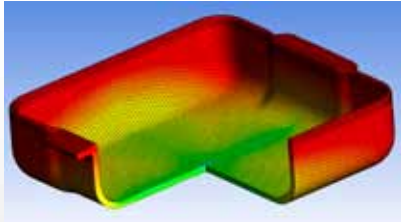
Food Extrusion



Very large deformation of the extrudate can be calculated in a purposely unbalanced die. Bingham models are used to reproduce the specific rheological behavior of food

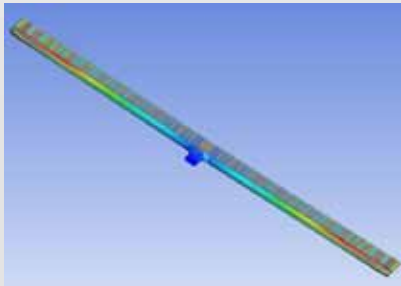
Application Solutions

Glass Pressing



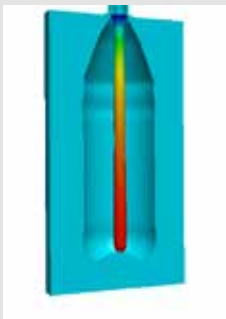
Temperature map in a glass pressed dish

Flat Die Extrusion



Contour lines of the velocity and particle trajectories in a flat die

Injection Stretch Blow Molding



Thickness distribution on the stretched preform for Injection Stretch Blow Modeling simulation using shell elements

Optimization and Design Exploration

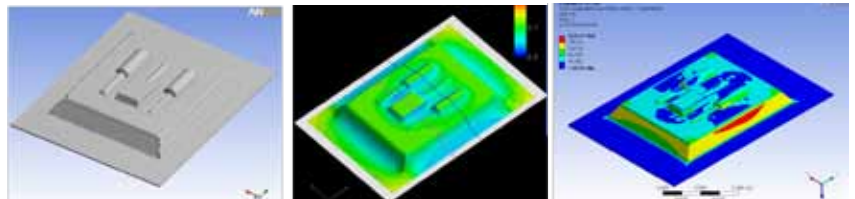
Designing equipment and processes for best results involves the evaluation of multiple designs and optimization of flow and geometric parameters. In ANSYS POLYFLOW, it is possible to declare any scalar as an optimization variable, including rheological parameters, boundary conditions and mesh displacements. Then the built-in optimization algorithm can be used to automatically minimize or maximize a given objective function based on input parameters. In ANSYS Workbench, ANSYS® DesignXplorer™ can be used to easily assess performance at multiple design points, perform DOE studies or compare several alternative designs. These capabilities allow users to seamlessly and automatically improve existing designs or to explore multiple design configurations.

Summary

ANSYS POLYFLOW is tailor-made for accurately modeling polymer, glass and metal processing applications. For organizations that need help to troubleshoot and optimize manufacturing processes, the software is proven to show a high return on investment. ANSYS POLYFLOW technology brings together unique capabilities for managing complex geometries, addressing advanced physics such as non-Newtonian viscosity, and specifying relevant operating conditions. The manufacturing process can be modeled properly and optimized faster and more cost effectively compared to addressing changes on the production line. The integration of ANSYS POLYFLOW into the ANSYS Workbench platform opens the door to virtual prototyping that can speed up design and manufacturing processes while improving end-product quality.

The ANSYS Advantage

With the unequalled depth and unparalleled breadth of ANSYS engineering simulation solutions, companies are transforming their leading edge design concepts into innovative products and processes that work. Today, nearly all of the top 100 industrial companies on the "FORTUNE Global 500" invest in engineering simulation as a key strategy to win in a globally competitive environment. They choose ANSYS as their simulation partner, deploying the world's most comprehensive multiphysics solutions to solve their complex engineering challenges. The engineered scalability of solutions from ANSYS delivers the flexibility customers need, within an architecture that is adaptable to the processes and design systems of their choice. No wonder the world's most successful companies turn to ANSYS — with a track record of 40 years as the industry leader — for the best in engineering simulation.



Virtual prototyping of thermoforming using ANSYS POLYFLOW and ANSYS Mechanical

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