# Comprehensive Flow Modeling Software for the Glass Industry

## Fluent CFD Software & Services

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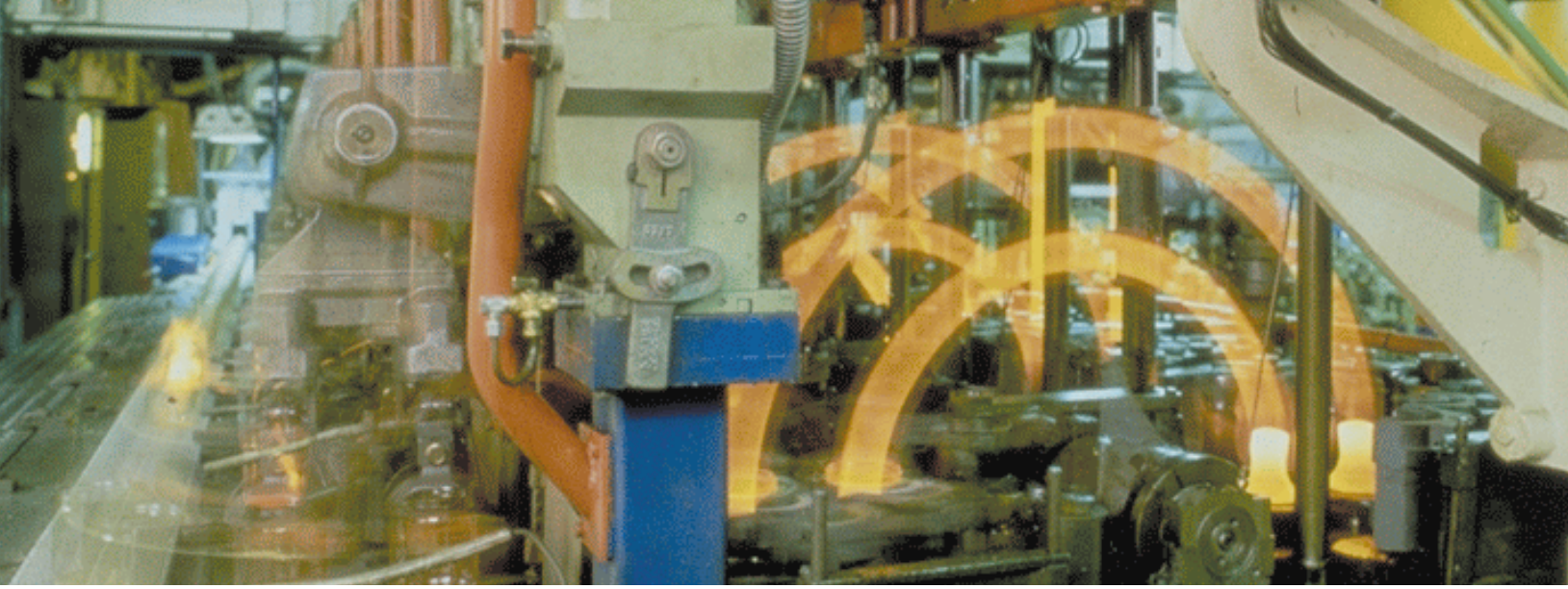


## IMPROVE GLASS QUALITY AND REDUCE COSTS WITH FLUENT

Flow modeling with computational fluid dynamics (CFD) software gives you insight into the physical, chemical and thermal processes which take place during glass production and forming. Fluent software models every stage of the glass making process, including the furnaces, melters, refiners, forehearths, and spout bowls. You can also model glass forming operations, such as drawing, pressing, blowing, and fiber production. The insight you gain with Fluent improves your designs, ultimately boosting productivity and reducing production costs and pollutant emissions.

We offer a suite of software products and services tailored to the diverse needs of the glass industry. Our software is backed by technical support and consulting from engineers who have significant expertise in simulating glass problems. It incorporates leading-edge numerics, algorithms and physical models relevant to the glass industry. Advanced pre-processing (geometry and mesh creation/import) and post-processing (visualization) tools are also included. The easy-to-use interface and unrivaled interactivity of our software makes it popular among researchers, designers and process engineers alike.

**"The (Fluent) models serve as a basis for more geometrically complex analyses that will allow us to optimize process improvements before time and money are spent on experimental testing."**

*Dr. Philip Burnside PPG Industries, Inc.*

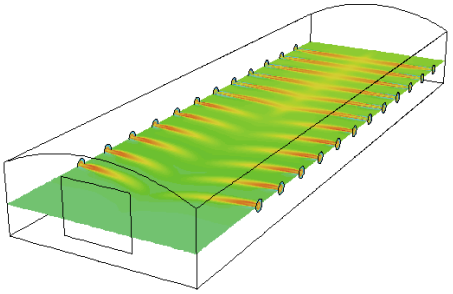
# Glass Production

In an industrial glass furnace, batch material is charged at one end and heated from the top to form glass which exits from the throat at the other end. Major considerations include: improvement of thermal efficiency, reduction of pollutant gas emission, identification and alleviation of glass defects, and enhancing production rate while improving glass quality and consistency. Flow modeling helps you to determine which changes in operating conditions and furnace designs will allow you to improve furnace lifetime, glass quality and pull rate, while reducing energy costs and emissions.

Glass furnaces are characterized by turbulent reacting flow in the combustion space, coupled with natural convection-driven laminar flow in the glass melt, heat transfer radiation and temperature-dependent glass properties. Our software handles this coupled combustion-glass flow including spectral, semi-transparent radiation.

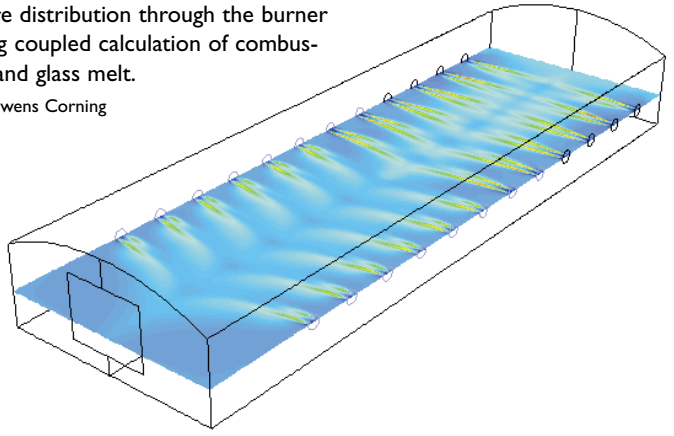
## Furnaces

Fluent software leads the field worldwide in combustion, turbulence and radiation modeling. In addition to standard models, our advanced capabilities include two mixture fraction/PDF and laminar flamelet models for combustion; RNG k-ε, realizable k-ε, Reynolds stress models for turbulence, and the discrete ordinates model for radiation. You can also use our software to model $NO_x$ formation and consumption due to reburn chemistry. These models help you to improve design and furnace performance.



Temperature distribution through the burner plane during coupled calculation of combustion space and glass melt.

Courtesy of Owens Corning



Mass fraction of $NO_x$ in the combustion chamber showing higher concentration near the flames.

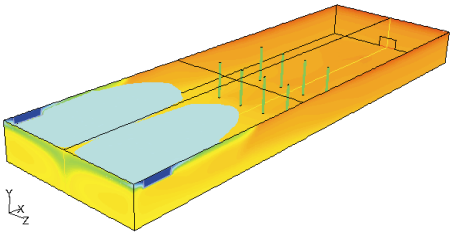
Courtesy of Owens Corning

## Melting

Glass melt simulation provides insight into batch melting rate, glass circulation patterns within the melter and near bubblers/electrodes, efficiency of thermal transport and mixing, and causes of defects such as chords, seeds, bubbles, and stones. Our models for batch melting, air bubbling, electrical boosting, and glass quality indicators enable complete simulation of melters.

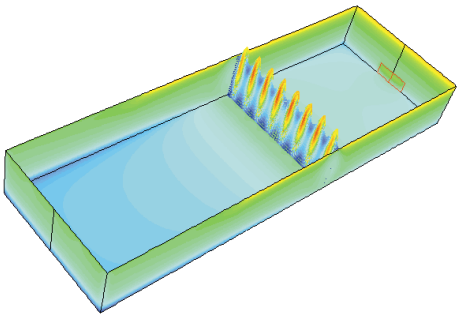
Our three-dimensional batch model couples the batch and glass melt and computes batch velocity. It is applicable to any furnace and accounts for chemical reactions and gas release during batch melting.

Our boosting model simulates three-phase electrical boosting. The voltages on the electrodes can be automatically adjusted to match the total power input.

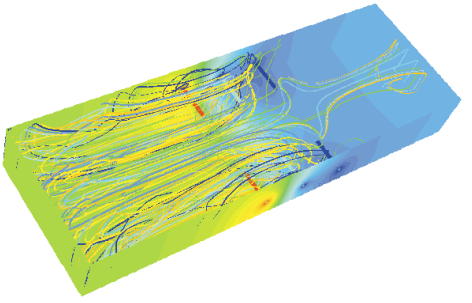


Batch concentration on the top of a glass melt and the temperature distribution on the walls shown with the location of bubblers and electrodes.

Courtesy of Owens Corning.



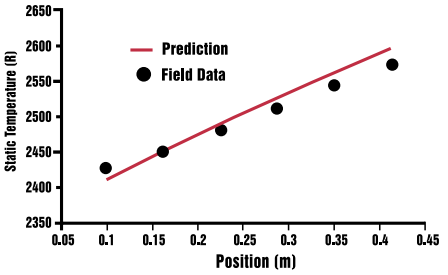
Contours of temperature on the walls of a glass tank and the velocity vectors through the plane of the bubblers.



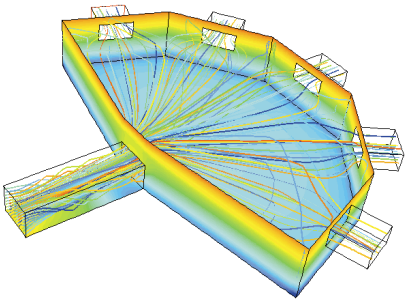
Contours of real voltage on the walls of a glass tank and electrodes. Particle pathlines are superimposed as well.

# Conditioning and Delivery Systems

The delivery system that bridges melting and forming plays an important role in conditioning the glass for downstream processing to ensure high quality and homogeneous thermal profiles. Flow modeling is used to guide and optimize the design and performance of delivery systems and evaluate factors that affect glass quality.



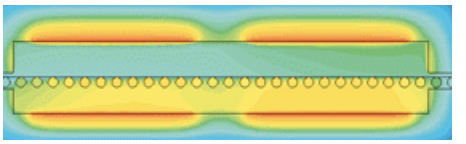

Vertical temperature profile in a glass delivery system. Courtesy of Owens Corning



Temperature distribution on the walls of a refiner shown with pathlines of particles injected from the inlet.

# Process Simulation

Fluent's diverse models for turbulence, dispersed and multiphase flows make it an ideal choice for modeling auxiliary equipment and processes in a glass plant, such as stirrers, air formers, hearths, reheat furnaces, spout bowls, lehrs, CVD, and coating.

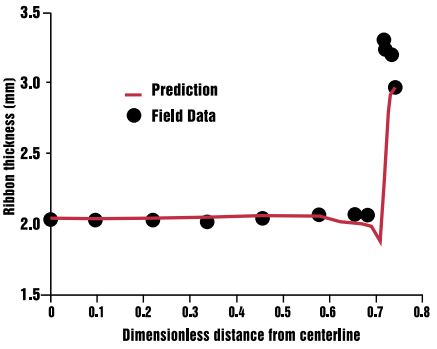


Temperature contours of a continuous glass sheet in a furnace with two heating zones.
Courtesy of PPG Industries

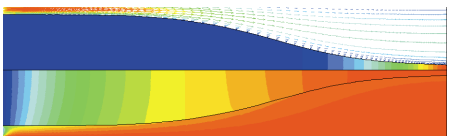
# Glass Forming

Flow modeling is a powerful means of understanding and optimizing operating conditions in glass forming.

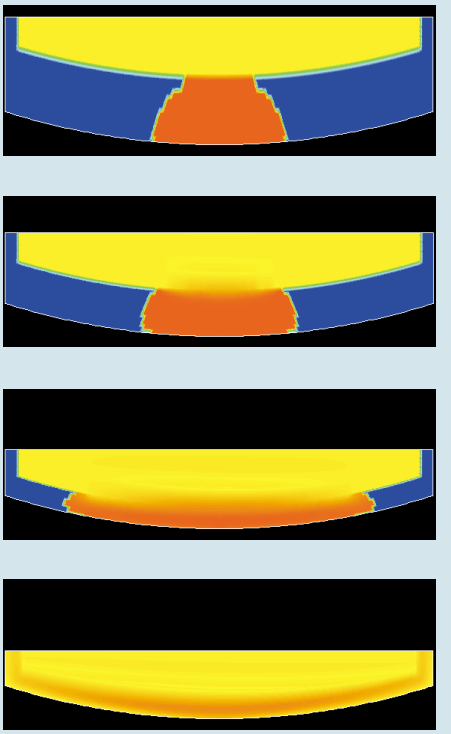
Glass forming operations are characterized by large free surface deformation, conjugate heat transfer, coupled flow of glass and the surrounding medium, and highly temperature-dependent viscosity. Our software enables you to simulate these complex phenomena accurately.



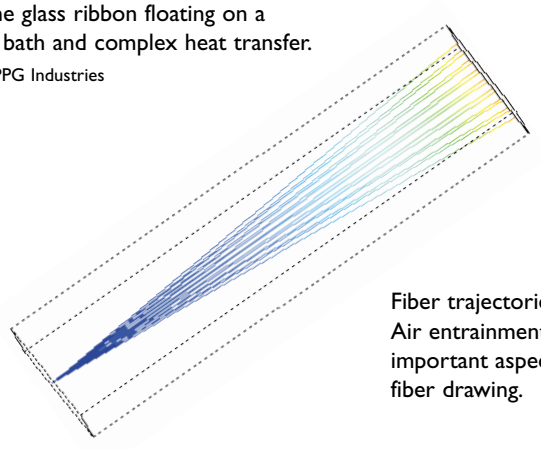

Prediction of ribbon thickness in float glass forming. This process involves large draw-down of the glass ribbon floating on a molten tin bath and complex heat transfer.
Courtesy of PPG Industries



Prediction of neck down, velocity and temperature in optical fiber drenching. Significant draw-down ratios, coupled flow of glass and helium, along with spectral radiation, characterize this process.



Coupled plunger motion and glass shape in a mold for making TV panels.



Fiber trajectories colored by temperature. Air entrainment and temperature are important aspects to study in continuous fiber drawing.

# CFD Benefits You

### IMPROVE UNDERSTANDING AND DIAGNOSE DEFECTS

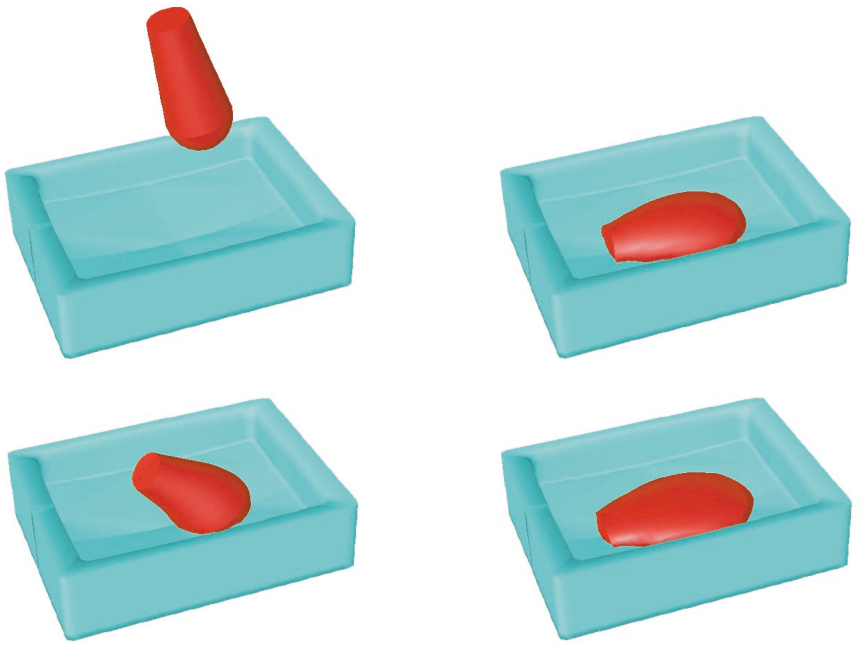
When you use CFD to study an existing process, you get a detailed description of the fluid flow, heat transfer and chemical reactions thereby gaining valuable insight. This insight helps you to understand and troubleshoot the cause of defects, build retrofits or other solutions, and improve productivity.

### IMPROVE PERFORMANCE

Performance of existing equipment, process and products is analyzed and optimized using CFD. This leads to improved productivity and reduced scrap rate.

### REDUCE DESIGN TIME AND EXPENSE

CFD enables you to evaluate and optimize performance of several design concepts before a physical prototype is built and tested. This reduces the number of design iterations and significantly reduces design cycle-time. CFD helps to guide physical testing, thereby reducing testing costs.



Gob shape is studied as the gob falls into a mold. Large free surface deformation and complex heat transfer are involved in this process.

## Fluent Delivers Solutions For:

- Burners
- Furnaces and Crown
- Melters
- Refiners
- Conditioners
- Stirrers
- Electric Melters
- Regenerators
- Lehrs
- Gob Feeder
- Float Glass Forming
- Annealing
- Glass Wool Manufacture
- Continuous Glass Fiber Drawing
- Bushings
- Air Formers
- Air Blowers
- Pollutant Formation
- Fans/Blowers
- Forehearths
- Air Bubblers
- Electric Boosting
- Batch Melting
- Spout Bowls
- Sheet Formation
- Product Forming (augers)
- Fiber Drawing
- Tube Extrusion/Drawing
- Glass Blowing
- Gob Formation
- Gob Falling
- Glass Pressing
- Coating
- Mold Filling
- Oxy-Fuel Conversion
- Chemical Vapor Deposition (CVD)
- Optical Preform
- Optical Fiber Drawing
- Pressure Coating
- Tube Coating

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When you choose Fluent, you choose the world's leading CFD software and consulting services, used today at more than 3000 sites worldwide. You also align yourself with a company that is dedicated to ensuring your success. Our staff of technical experts takes pride in offering the services you need:

## TRAINING

Our comprehensive, customized training courses teach you how to apply CFD to your design and analysis problems. You'll work with our technical support staff to learn how to plan the analysis, use the software and interpret results.

## TECHNICAL SUPPORT

The relationship that started during training is strengthened as we stand behind you with unlimited technical support. Successful use of CFD depends on quality support, and we are renowned for providing it.

## CONSULTING

When your organization chooses to use external manpower and resources for CFD analysis, our consulting staff can help you. Many of industry's leading fluid flow experts are on our staff and are ready to assist with anything from turnkey solutions to application specific software development. We also make high performance computing resources available to you for analysis of unusually memory-intensive problems.

# *Your partner in flow modeling*

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Furnace Photograph Courtesy of
Combustion Tec, Inc.