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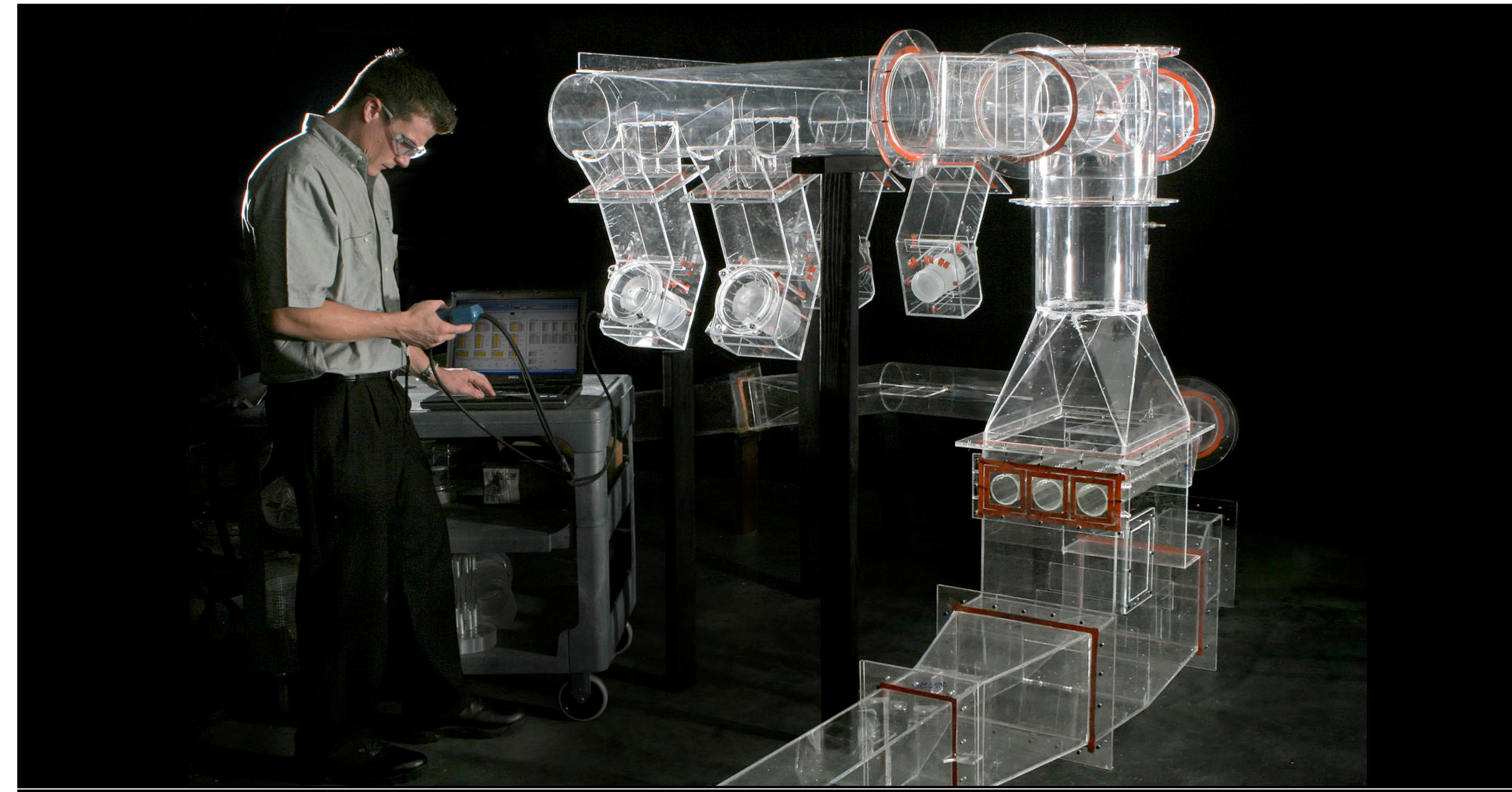


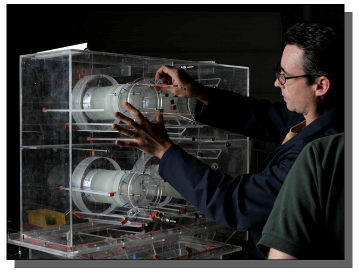
SMART*flow*™ Technology Center

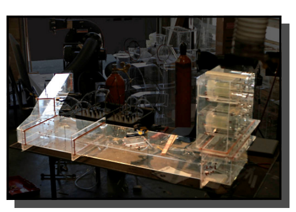
Process

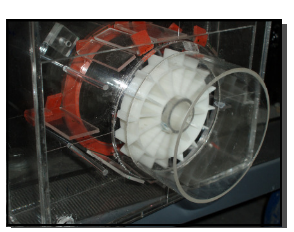
Power

Industrial

SMART*flow*™ Advanced Physical Flow Modeling







The most common application of flow modeling is combustion air flow. Burner design and performance is always based on three assumptions; flow modeling assures that what actually takes place will correspond to these assumptions:

- Each burner (applicable in multi-burner systems) gets equal amounts of air flow.
- Air enters the burner evenly around the periphery of the burner.
- Air enters the burner radially, that is, with no tangential components.

HOW IT WORKS

In order to produce predictable, and satisfactory, flame characteristics, it is necessary to provide accurately air and fuel flow, together with evenly distributed flows within the burner(s).

A customized, clear Plexiglas 3-dimensional model is constructed, typically 10:1scale, that includes all internal components (trusses, expansion joints, etc.).

Quantitative measurements are made by flowing air through the model using venturi meters, static probes, and orifice plates. These instruments generate differential pressures that are measured with various types of devices (manometers, etc.). In addition, bulk flow rates through the register are measured and compared directly using a venturi meter specifically designed and developed in the technology center; this instrument engages the throat of the burner without impeding flow.

Velocity distributions within the register are determined by traversing the throat with a pitot static tube. Proportionate deviations from the mean velocities may then be recalculated, polar diagrams may be drawn, and bulk flow rates computed by both graphical and numerical surface integration.

Once areas of improvement are indentified, these tests are repeated with a series of modifications based on Hamworthy Peabody Combustion's many years of combustion experience. Mass flow differences for each burner in multi-burner systems shall be considered acceptable when within ± 2% of mean, with a goal of ± 1%. Peripheral velocity deviations in the model shall be considered acceptable when within ± 10% of the mean velocity.

Upon completion of the analysis, the results are detailed in a written report that includes a description of the physical model, model assumptions, boundary conditions and photographs, graphs, and data tables. The results cover the "as-is" conditions of the system, as well as the results of adding the recommended flow distribution devices. A complete set of drawings showing the locations of baffles, turning vanes, etc. required to ensure proper air distribution are supplied.

Pre and post testing of the boiler equipment is highly recommended to ensure the model's effectiveness.

The result is a practical and cost-effective solution to many existing combustion problems. For new installations, this modeling technique assures performance and minimizes start-up time by eliminating many flow issues before they occur.

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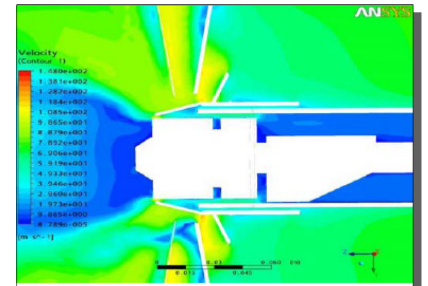
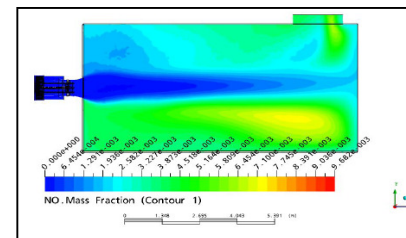
SMART*flow*™ Technology Center

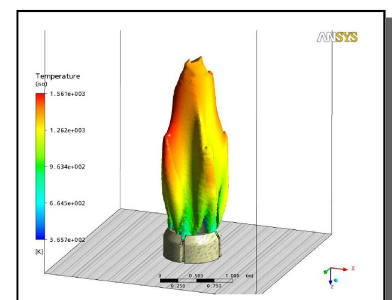
SMART*flow*™ CFD Modeling



Velocity profiles used to design nozzles



Prediction of NO production by CFD



SMART*flow*™ Computational Fluid Dynamics can be used to quickly, and accurately, model critical parameters in the design, analysis, and troubleshooting of critical combustion processes, including (but not limited to) the following parameters and the interaction of these parameters:

- Flow of Multiple Fluids (e.g. Fuels, Air, Flue Gases, etc.) and their Interaction
- Temperature, Heat Release Patterns, and Heat Transfer
- Velocity
- Flame Dynamics, Shape, and Interactions
- Emissions
- Particle Size

This results in a very precise visualization and prediction of what takes place, as well as the ability and flexibility to quickly make changes based on Hamworthy Peabody Combustion's many years of experience. We can then determine the results of these changes without time-consuming trial & error testing, costly fuel consumption, and downtime on the jobsite.

HOW IT WORKS

Physical flow modeling represents an actual flow profile of a system, including velocities, pressure drops, disruptions in flow, turbulence, etc. **SMART*flow*™ Computational Fluid Dynamics** represents these same parameters as well as others, including temperature, particle size, etc.

Computational Fluid Dynamics (CFD) provides predictions of system dynamics, such as in-furnace reactions, without costly and time-consuming on-site testing. This modeling is done using specific, calculated assumptions to design a virtual model of the system. The software downloads from actual CAD drawings of the physical system, whether it be piping, windbox and furnace, atomizer, gas nozzles, etc., to assure accurate representation. Fluid (air, fuel, flue gas, etc.) inputs are emulated, and conditions adjusted and re-designed to then evaluate the change in results.

While CFD Modeling can be used alone, Hamworthy Peabody Combustion recommends using this CFD Modeling in conjunction with Physical Flow Modeling to confirm the flow inlet boundary conditions of the virtual model. Once the flow parameters are confirmed, other results of the CFD modeling are assessed. When needed, these results can be further confirmed with actual test-rig firing at Hamworthy Combustion's Advanced Technology Center.

This design process has been utilized in developing many of Hamworthy Peabody Combustion's new products, as well as upgrading existing products in order to meet today's environmental and economic needs. It has also proven invaluable in assessing customers' existing combustion problems, increasing efficiency, and decreasing emissions.

HAMWORTHY Peabody COMBUSTION