

Warming Up to Direct Modeling

Advanced CAE model preparation enhances pellet stove design and optimization.

By Andrea Tezza, Mechanical Engineering, Extraflame Technical Department
La Nordica-Extraflame, Vicenza, Italy



Extraflame Rosy™ pellet stove with nominal thermal power of 2.5 to 5.0 kW, total efficiency exceeding 87 percent and an hourly pellet fuel consumption of 0.6 to 1.2 kg/hr

Customer preference and restrictive international regulations related to energy efficiency have pushed heating appliance manufacturer Extraflame to make significant investments in R&D. La Nordica-Extraflame is a leader in the field of heating appliances, with 35 years' experience in manufacturing pellet-burning stoves, wood stoves, fireplace inserts and boilers. Pellet- and wood-burning stoves have gained popularity in recent years as fossil fuel prices soared. Both wood and wood-pellet fuels are carbon neutral by definition: Burning wood does not release any more carbon dioxide than the eventual biodegradation of the unburned wood. In fact, 2.3 kilograms of dried wood provides the equivalent calorific power of 1 liter of diesel oil or 1 cubic meter of natural gas — even though wood fuel is priced up to 50 percent less than diesel oil or natural gas.

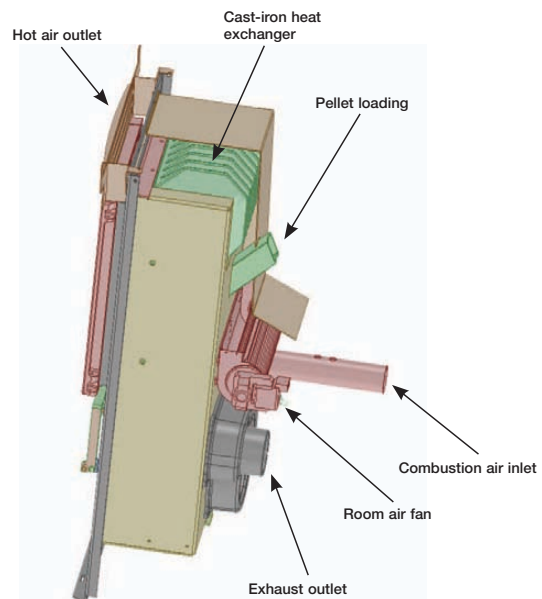
Within these appliances, combustion of pellets or wood increases the temperature of the hot exhaust stream within a plate heat exchanger (built into most models). Air or water is, in turn, heated by the heat exchanger and then circulated throughout the space.

Extraflame started using fluid dynamics software from ANSYS in 2009 to perform studies on stoves that use wood or wood pellets as the primary fuel source. Analysts conduct detailed component-level fluid flow analysis, such as heat exchanger optimization to improve unit efficiency, which reduces fuel consumption while providing consistent heat. However, the company realized that geometry model preparation was a bottleneck to Simulation Driven Product Development.

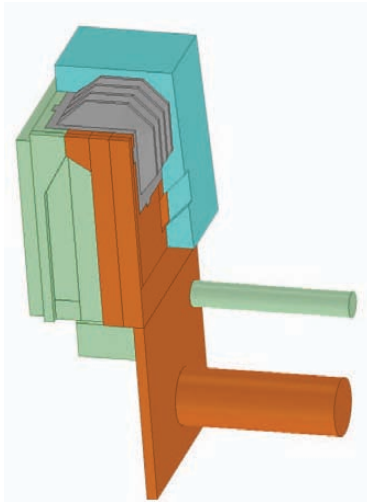
Even though most Extraflame analysts have some familiarity with traditional CAD systems, access to these tools is not always available. The engineering team recognized that defeaturing a dirty geometry model in traditional CAD can be painstakingly laborious. To better equip analysts for this work and to streamline the process, the department considered both the ANSYS DesignModeler tool and ANSYS SpaceClaim Direct Modeler, with the latter selected in 2010.

Whether updating an existing model or designing a new unit from scratch, the CAD department at Extraflame provides detailed geometry models for analysts' use. These geometries are sometimes shared in native CAD format but, more commonly, the transfer occurs using STEP. The ability to import a broad range of geometry formats was an inherent requirement for selection of the analysts' geometry tool. Additionally, with a direct modeling tool available that is compatible to ANSYS Workbench, Extraflame analysts can build geometries from scratch to facilitate concept studies, prior to any detailed design models being created by the CAD department.

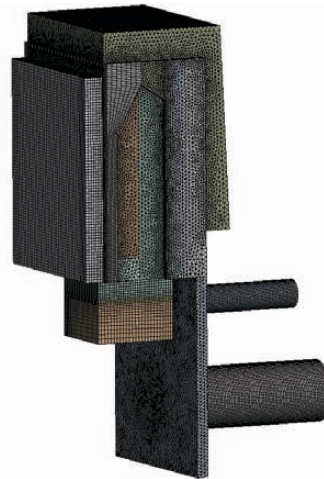
When the CAD group provides a detailed design model, analysts perform the defeaturing, cleanup and healing operations, and flow volume creation from solid geometry. This geometry may be adjusted and controlled as part of the optimization process. When a geometry is



Detailed CAD model for residential 4 kW (thermal) pellet stove



To perform flow and optimization analyses, each stove (residential or commercial, wood or wood-pellet fuel source) must be decomposed into two flow volumes: one for the fluid circuit, which circulates air or water to occupant spaces, and one for the combustion circuit, which comprises the combustion air intake and outlet. A plate heat exchanger passes thermal energy from the hot exhaust stream to the fluid circuit.



Hybrid meshes applied to decomposed flow volumes using ANSYS Meshing within the ANSYS Workbench environment

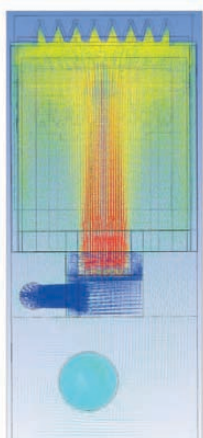
ready for analysis, an associative interface passes the geometry to ANSYS Workbench. Meshing, solution and post-processing are all performed within the ANSYS Workbench environment.

Using ANSYS SpaceClaim Direct Modeler, creating the internal flow volumes in a pellet stove is straightforward. The analysis team caps pipes using the **Fill** command, which then can be dragged using the mouse and the **Pull** command along the axis of the pipe, automatically creating flow volumes. Dragging the face in the opposite direction extends the pipe volume away from the original domain, which is advantageous at inlets to allow the flow field to fully develop prior to reaching the area of interest. For larger, complex models, the **Gaps** and **Missing Faces** commands under the repair tab are helpful for healing problematic geometry. Artificial intelligence built into the GUI takes considerable pain out of the process relative to standard CAD.

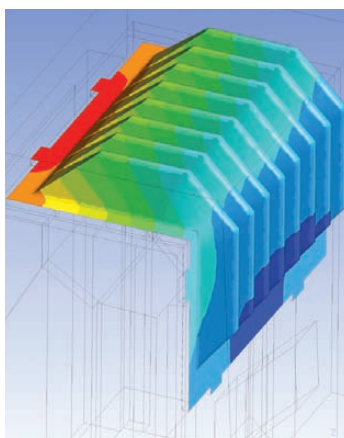
The **Split Edges** command is important for eliminating coincident, redundant edges, which commonly exist when working with STEP geometry. Small holes, such as bolt holes that need to be closed as part of this process, can be automatically detected and closed using the **Fill** command. The geometry is simplified by eliminating non-essential parts. The objective is to create two independent flow volumes, one for the exhaust gas stream and the other for the heating medium — either water or air, depending upon the unit. These two flow volumes intersect at the stove's plate heat exchanger, which facilitates energy exchange from the hot exhaust stream to the heating medium. The team typically can make analysis-ready geometry within a few hours.

Because of the dedicated interface to the ANSYS Workbench platform, analysts can move from geometry to analysis and continue to update the geometry and restart the case without tedious re-work. Following optimization, design changes are provided back to the CAD group so production models may be updated. The annotation utilities in the direct modeler can be used to document final dimensions for reporting purposes. Alternatively, the team may write out the final geometry from the ANSYS product using STEP (or other neutral formats) so designers can compare the proposed changes with the initial detailed model directly within the CAD tool.

The introduction of ANSYS SpaceClaim Direct Modeler along with ANSYS CFX fluid dynamics software tools has had a significant impact on product development at Extraflame. Design time has been halved on average. Moreover, reliance on physical testing has been significantly reduced, with the number of physical prototypes moving from several to one for a typical project. Thermofluid simulation at Extraflame now drives and connects the CAD design activity to the product's final design.



Hot exhaust gas stream passing through the plate heat exchanger in the stove



Temperature gradient across the surface of the plate heat exchanger