Coupling the Flow Model to the Thermal Model

In TMG, hydraulic elements model one dimensional flow through the duct network but they are also part of the thermal model. Convection provides the heat path between the fluid model and the thermal model.

Fluid dynamics plays an important role in convection, especially in the boundary layer zone. Because of the complexity of the phenomena, a simplified approach must be taken to arrive at a value for the convective heat transfer coefficient.

TMG can model forced or free convection. In forced convection, the fluid is impelled by a mechanical energy source, typically a fan or pump. In free convection, the fluid is not moving except near the convecting surfaces, where displacement results from a density change due to heating.

Forced convection in TMG can only occur in a duct network. Heat transfer takes place between the beam elements of the duct network and adjacent shell elements that are part of the thermal model. The beam elements have fluid material properties while the shell elements have solid material properties. TMG employs standard correlations for convective heat transfer in fluid networks to determine local heat transfer coefficients.

TMG models free convection two ways, free convection to an ambient environment and free convection in a duct network.

When modeling *Free Convection* to ambient temperature and pressure, no fluid elements are required. Selected shell elements convect to the ambient fluid based on the correlation and characteristic shape you select. The correlations are derived experimentally and are applicable to specific geometry. Large differences between the model and the correlation's typical shape will result in a loss of precision.

Correlations exist also for modeling *Free Convection* within a duct network. The shell elements convect to the adjacent fluid elements based on the correlation and characteristic shape you select.

The correlations used for *Free Convection* assume a still air condition; when modeling "chimney effects" a *Forced Convection* entity provides a more accurate correlation.

Buoyancy Modeling

If your model involves buoyancy effects in a channel, you should use a duct network to analyze it. The channel length and the size and shape of its cross-section do not matter as long as the flow channel can be defined. This is the recommended method for modeling "chimney effects".

The effects of buoyancy are automatically calculated whenever fluid elements (duct networks) are detected. In solving the flow model, TMG computes density changes in the fluid using the ideal gas law. The resulting buoyancy forces in the system are also modeled by calculating a pressure rise across an element equal to

$$F_b = g \times (\varrho - \varrho_{amb}) \times \Delta height$$

Whether to model the convection to and from the buoyancy driven flow with *Free* or *Forced Convection* depends entirely on the physics of the flow.

Free convection is used for a still body of gas where some movements occur near the convecting surfaces. This could apply to a duct network with a very large cross-section.

If a velocity profile is developing across the channel cross-section, the *Forced Convection* correlations will be more accurate.

When modeling *Free* or *Forced Convection* always define a gravity vector in *Ambient Conditions* because of the buoyancy effects.
