



CFD Analysis of Temperature, Humidity, and Velocity Stratification inside a Mixing Box

Background:

A vast majority of mixing technologies offered by Blender Products Inc. are applied to AHUs to combat stratification inside an economizer section or mixing box. In these applications, one of the main objectives is to eliminate freeze-stat trips and frozen coils. In addition to addressing the root-cause of temperature stratification inside an AHU, enhancing the uniformity of the airstream to other downstream sections in the AHU provides operational benefits. This technical bulletin looks at the Channel Blender® ability to enhance the uniformity of airflow leaving a mixing box.

CFD Model and Assumptions:

To aid in our analysis, a CFD model was completed for an AHU with a plenum that is 140" wide and 110" high. The mixing box had a section length of 54". Total supply air flow is 44,000 CFM with 25% OA at 16°F while the RA is at a temperature of 70°F. The Mixed Air temperature is 55°F.

Modeling software: STAR-CCM+ Version 13.04

Boundary Conditions:

- Inlets: Duct extensions are added to provide a clean boundary condition. Incoming air temperature and flow rate are specified for each inlet.
- Outlet: The outlet is located at the upstream face of the filters. A pressure drop consistent with the pressure drop across typical filters is used. It is understood that there will be some amount of mixing and homogenization between the filters and the coils. That additional mixing is minimal under normal conditions and not studied to reduce model complexity.

Model Physics:

- Includes conservation of mass, momentum, and energy
- Steady-state turbulent models are used
- Ideal gas law is used to determine air density
- Effects of gravity and buoyancy are included
- Similar models were studied to determine the appropriate mesh resolution
- Excluded to increase computational efficiency
 - Actuators
 - Damper linkages
 - Small details (rivet heads, etc.)

Results:

The CFD model of the mixing box without any mixers is shown in Figure 1.

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CB-Tech Bulletin-114

Rev: 00

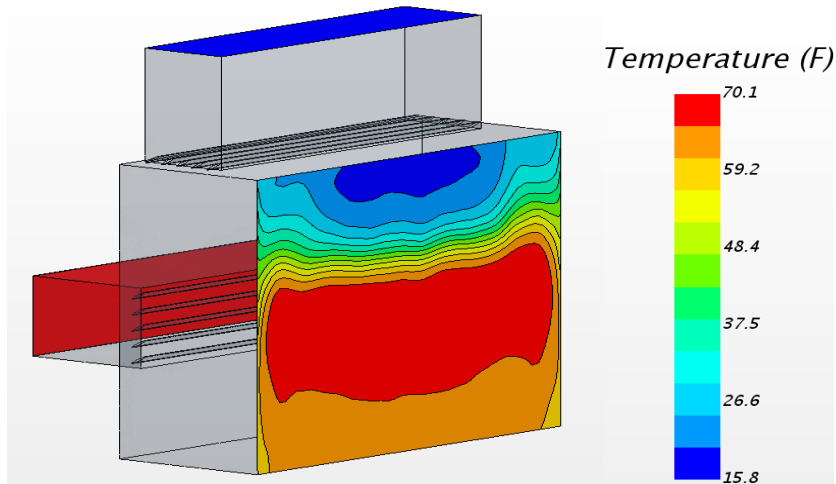


Figure 1: Temperature Stratification for case without Channel Blender

The minimum temperature at the face of the filter is 19°F. In this case the cooling coil of the AHU will not be adequately protected.

Integrating a Channel Blender® into the same mixing box significantly reduces the amount of temperature stratification exiting the mixing section. With the control dampers integrated into the Channel Blender®, the minimum temperature at the filter face is 46°F. It is worth noting, **no additional tunnel length is required** when integrating the Channel Blender® inside the mixing box.

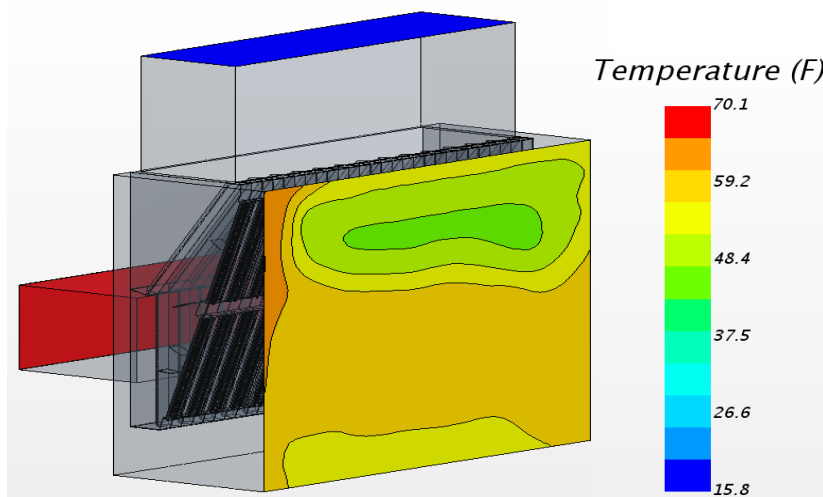


Figure 2: Temperature Stratification of Standard Mixing with Channel Blender

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CB-Tech Bulletin-114

Rev: 00

In addition to temperature stratification, the Channel Blender® improves airflow uniformity for downstream components (e.g., coils, filters). The results below demonstrate the ability of the Channel Blender to improve performance of the AHU under summer conditions (OA: 90°F DB/75% RH; RA: 70°F DB/60% RH). The mixed air temperature in all cases below have a setpoint of 75°F. The contour plots below look at the moisture loading, humidity mixing, and velocity maldistribution in an effort to demonstrate how the mixers can potentially improve cooling coil performance.

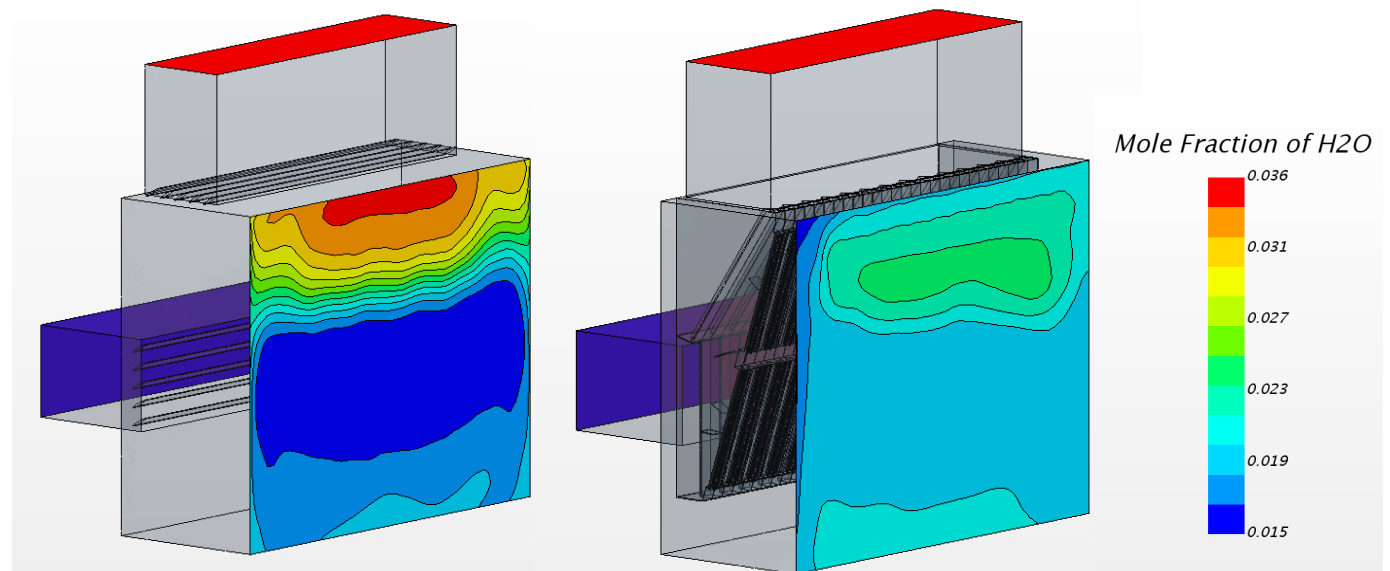


Figure 3: Contour Plots of the Water Mole Fraction for No Mixer and Channel Blender Cases

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Rev: 00

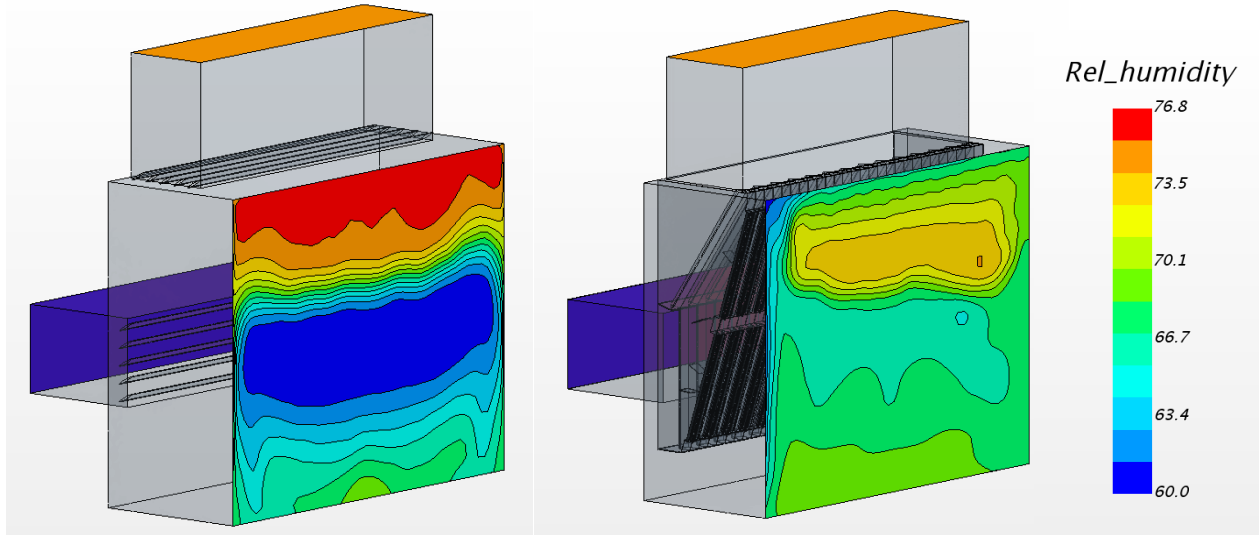


Figure 4: Contour Plots of the Relative Humidity for No Mixer and Channel Blender Cases

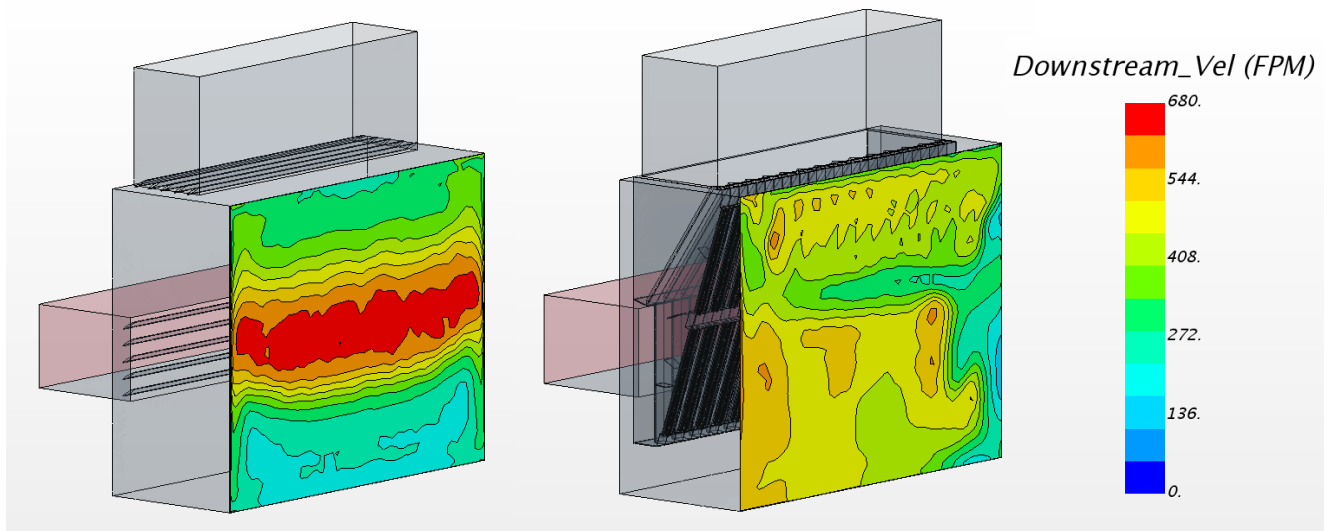


Figure 5: Contour Plots of the Downstream Velocity for No Mixer and Channel Blender Cases

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To compare the uniformity of the water mole fraction, the relative humidity, and the downstream velocity it is useful to use an RMS value. In this context the RMS is defined as the standard deviation of the variable (σ) divided by the mean of that variable (μ). Both the mean and standard deviation are evaluated at the upstream face of the filters. A lower RMS value is indicative of a more uniform distribution.

$$RMS = \frac{\sigma}{\mu}$$

As shown in Figures 3 - 5 and the table below, the addition of a Channel Blender® greatly improves the uniformity of the humidity and velocity of the air entering the filters and/or coils. **The Channel Blender® does not require any additional AHU tunnel length compared to other mixing technologies available.**

	H2O Mole Fraction RMS (%)	Relative Humidity RMS (%)	Velocity RMS (%)
No Mixer	31.7	8.5	37.0
Channel Blender®	8.6	3.5	19.5

Table 1: Uniformity of the Water Mole Fraction, Relative Humidity, and Downstream Velocity for No Mixer and Channel Blender Cases

Conclusions:

This analysis demonstrates that the addition of a Channel Blender® can significantly improve uniformity of the humidity and velocity of air moving through a cooling coil of an Air Handling Unit. This improved uniformity should improve coil performance.