Cable Bundle Geometry Effects on Internal Air Flows of Electronic Chassis

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Abstract

The vast majority of air flow analyses are performed to determine the associated heat transfer coefficients and eventually the thermal environment of an electronic enclosure/chassis are more concerned with the internal air flow field than the external air flow field[1][2]. This study is also concerned about the internal air flows but, with the inclusion of evaluating the effects of external cabling or other obstructions and how they influence the internal flows.

Table of Contents

Introduction

For this work, three different design configurations were analyzed. These design configurations were 1) no cable bundles in front of the electronic enclosure 2) Cylindrical bundle of cabling in front of the electronic enclosure and 3) A flat bundle of cables. The cable bundles assumed a nominal diameter of 0.375 inches and could consist of either network cables or fiber optic cables. The CFDesign 2011 program was used to perform the air flow analysis.

The three configurations modeled and analyzed are provided in Figures 1, 2 and 3 as images from SolidWorks 2010, the program used to model the configurations. The transparent volumes in front of the electronic enclosure in Figures 1 through 3 are provided to represent the air as it enters and leaves the enclosure.

Related Work

A number of prior CFD flow field simulations were performed to determine the flow characteristics of the electronic enclosure represented in Figure 1. These flow simulations initially characterized the flow of individual electronic modules. The individual module flow loss models were then developed and input into the overall flow model to simplify and reduce the number of elements modeled.

Figure 1 - No cable bundles

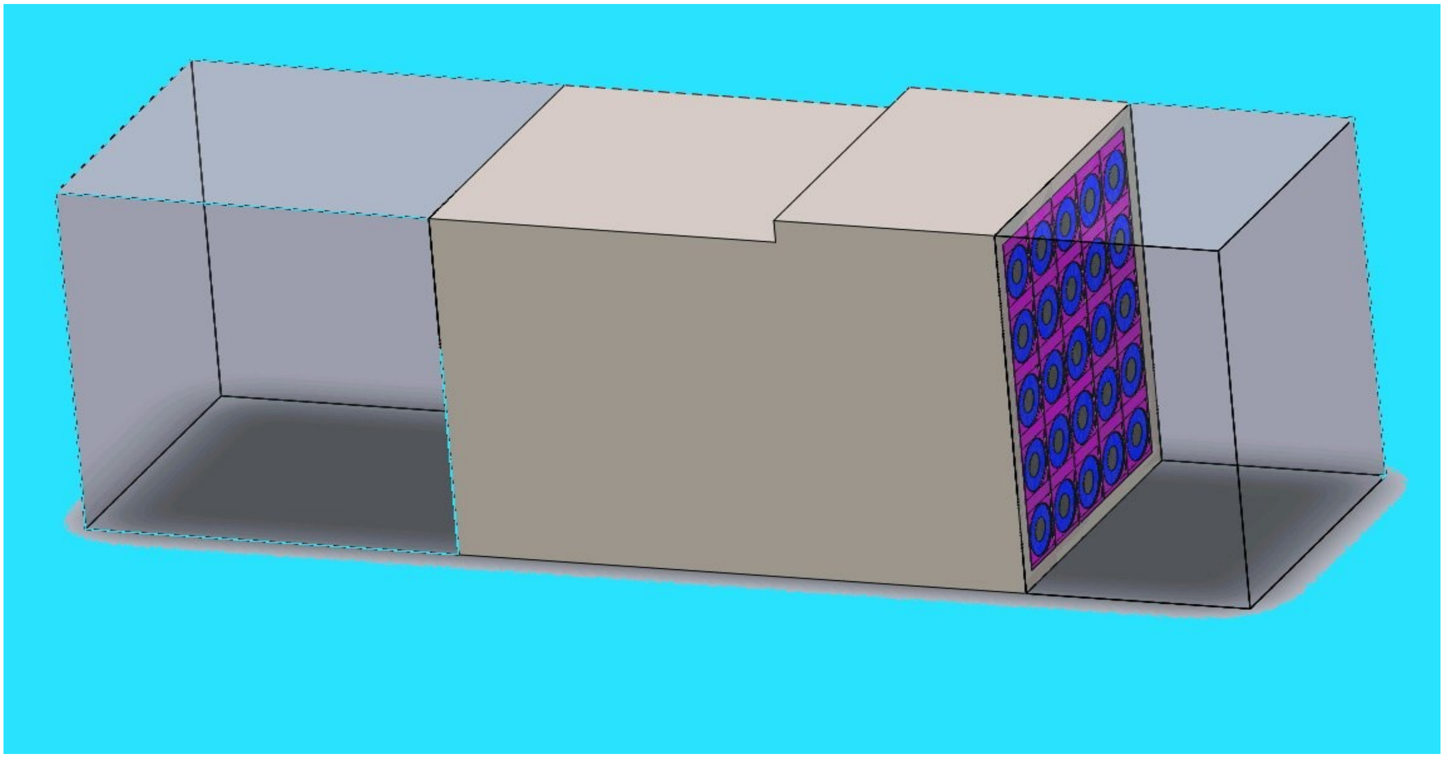


Figure 2 - Cylindrical Cable Bundles

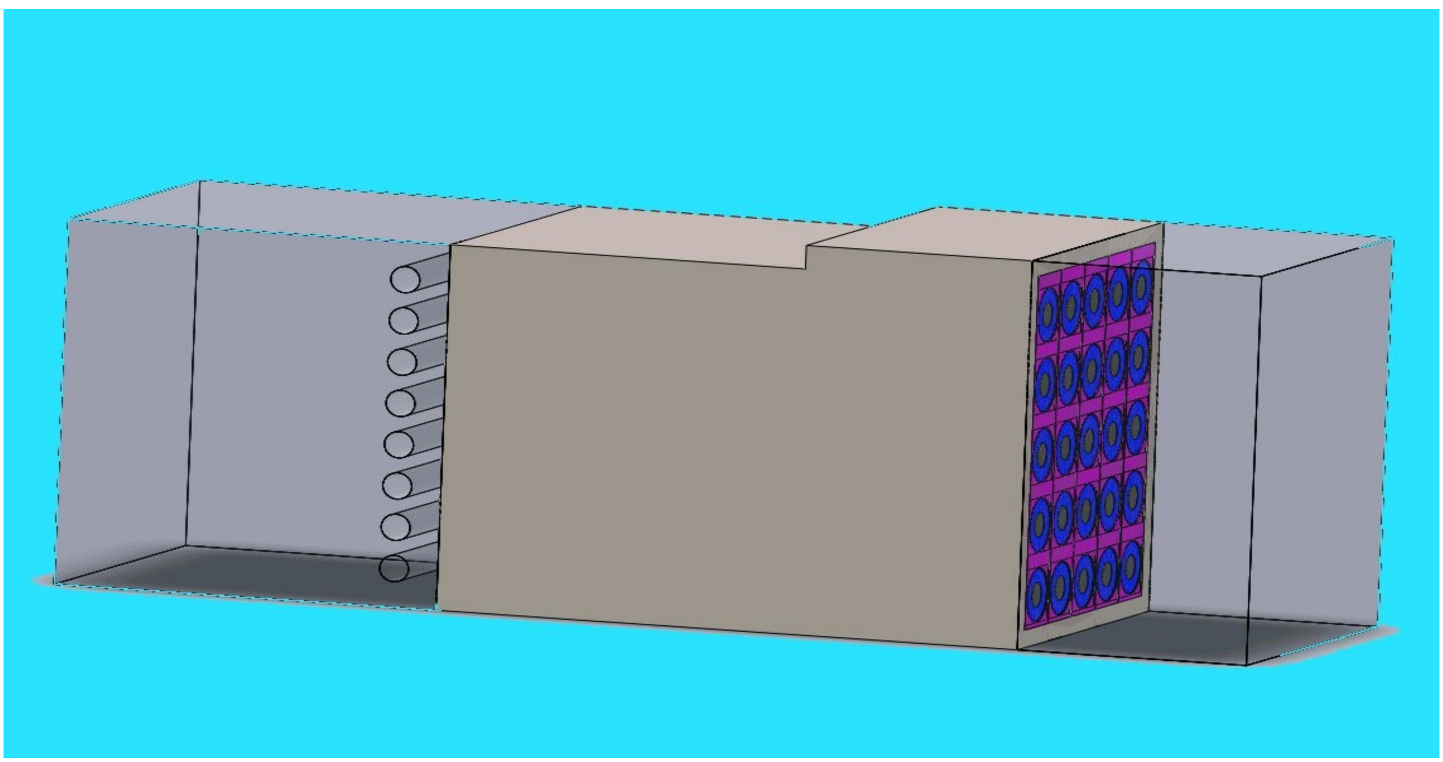
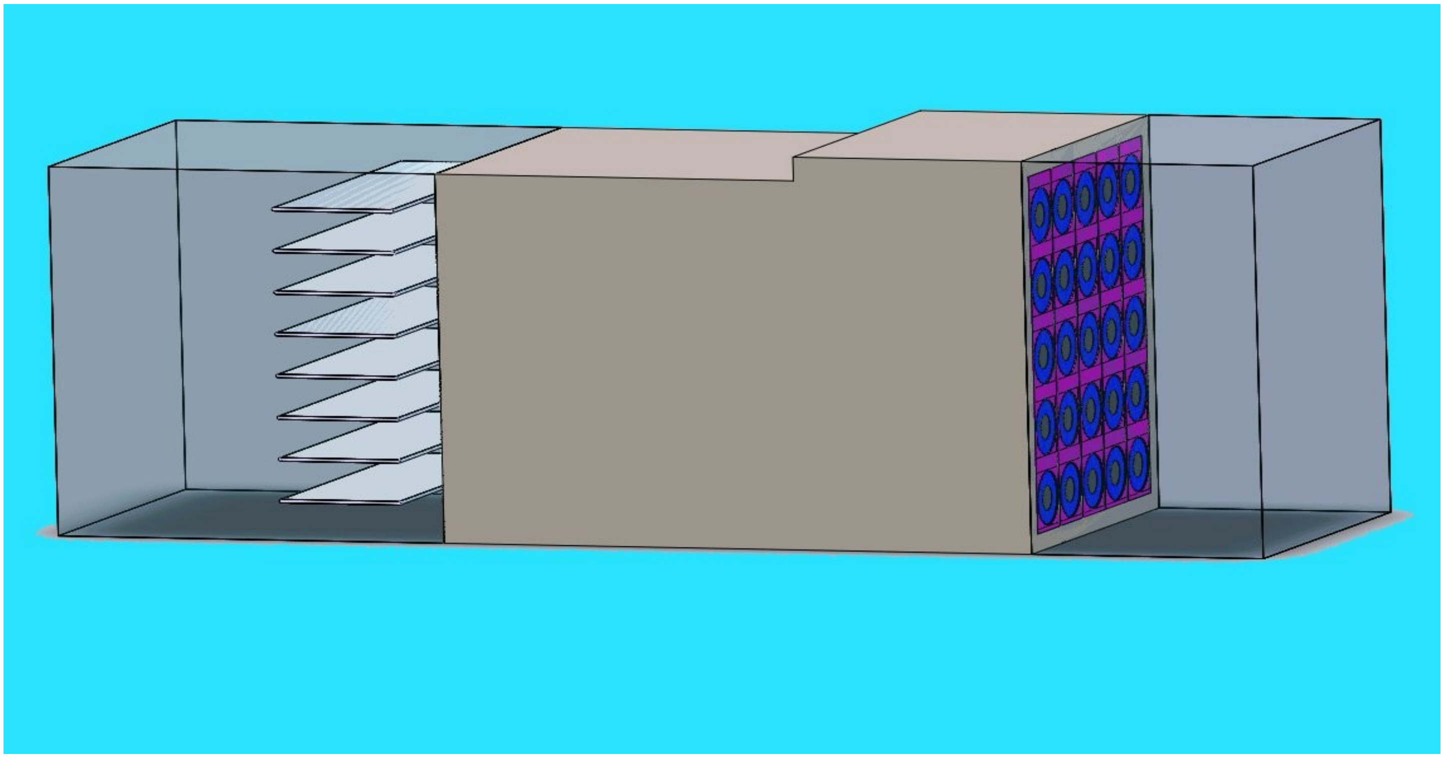


Figure 3 - Flat Cable Bundles



Analytical Assumptions

The analytical assumptions used in this work are there is zero air velocity at all surfaces. Thermodynamic properties of the air were at 50 degrees centigrade with density and pressure for 10000 foot altitude from standard atmospheric charts. The flow was assumed to be incompressible because the flow velocities are below the sonic level. A zero pressure at the very front and rear surfaces of the modeled air volumes was assigned to approximate the surrounding environment. Also, the mesh sizes for all configurations modeled in this study were the same with the exception of enhanced modeling around the cable bundles on the two models with cable bundles.

Another interesting assumption is the flow resistance of each circuit board assembly was assigned to occur at the ventilation openings for all PCB assemblies. This data was obtained from previous CFDesign runs for the PCB assembly by itself. This assumption was used to simplify the model and reduce element count and subsequent computer run times. One short coming of this assumption is, it does not prevent the formation of large vortexes from forming numerically when in reality the formation of a large vortex would be prevented by the flow separation and straightening flow effect provided by the almost completely full length and width PCBs and supporting sheet metal.

Results

The results of the finite element CFDesign runs are provided as color depictions of the flow fields in Figures 4 and 5 for the design configuration with no cables modeled, Figures 6 and 7 for the design configuration with the cylindrical cable bundles and Figures 8 and 9 for the design configuration with flat cables provided.

In the following figures, colors correspond to various velocity ranges. For example the red color corresponds to flow velocities from 1800 to 2000 feet per minute and the orange color corresponds to the velocity range of 1600 to 1800 feet per minute.

Flow Velocity Results

For the flow results of the two cable bundles, both cable bundles were located the same distance from the trailing edge to the electronic enclosure. The basic direction of air flow was from left to right on the page or from front to back of the unit. The 5x5 array of 25 fans were configured as pull through instead of push through.

Figure 4, No Cable bundles - 3D View

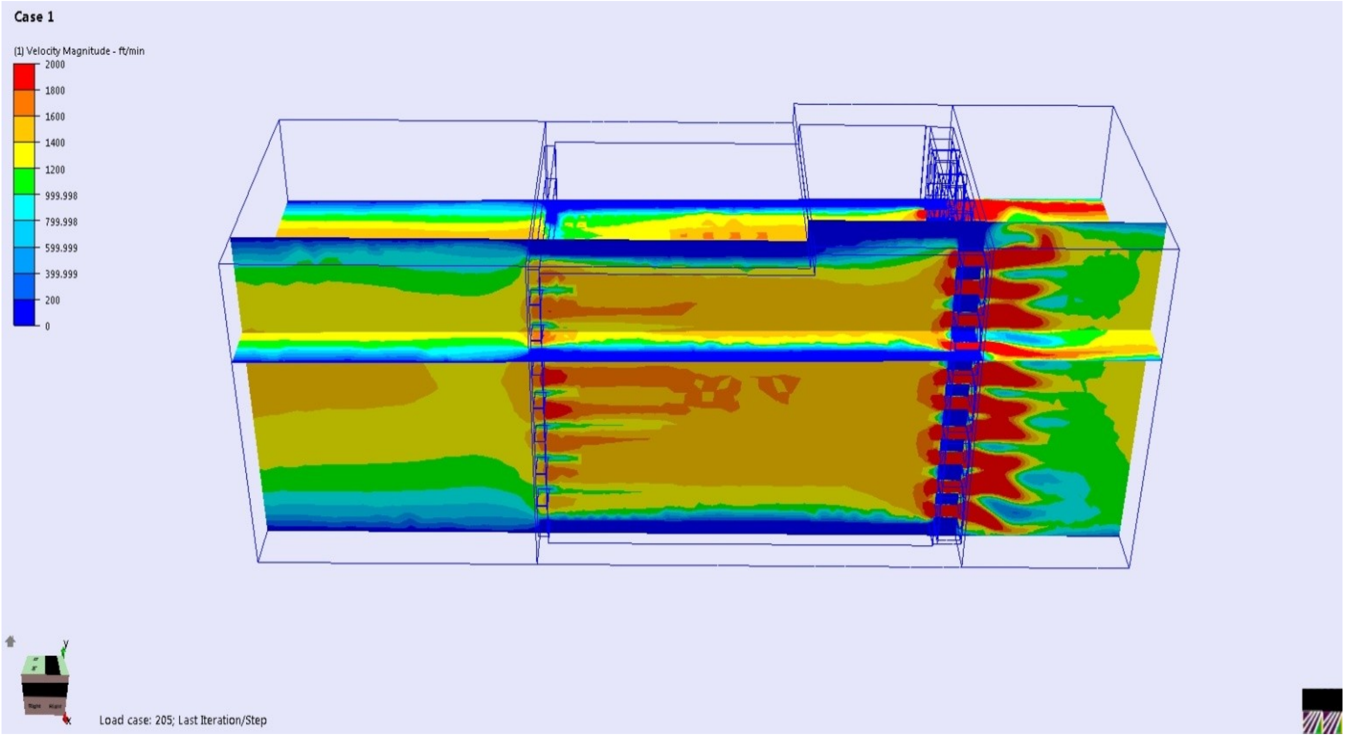


Figure 5, No Cable Bundles - Side View

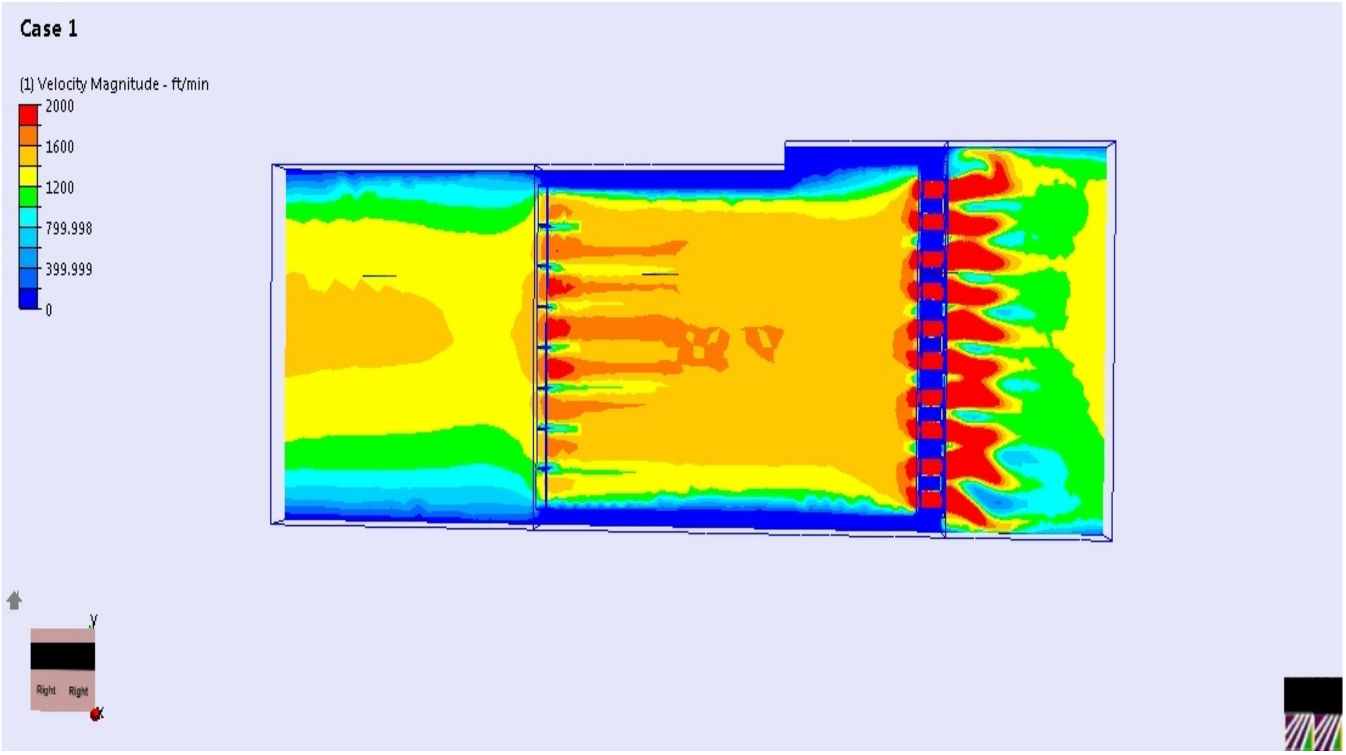


Figure 6, Cylindrical Cable bundles - 3D View

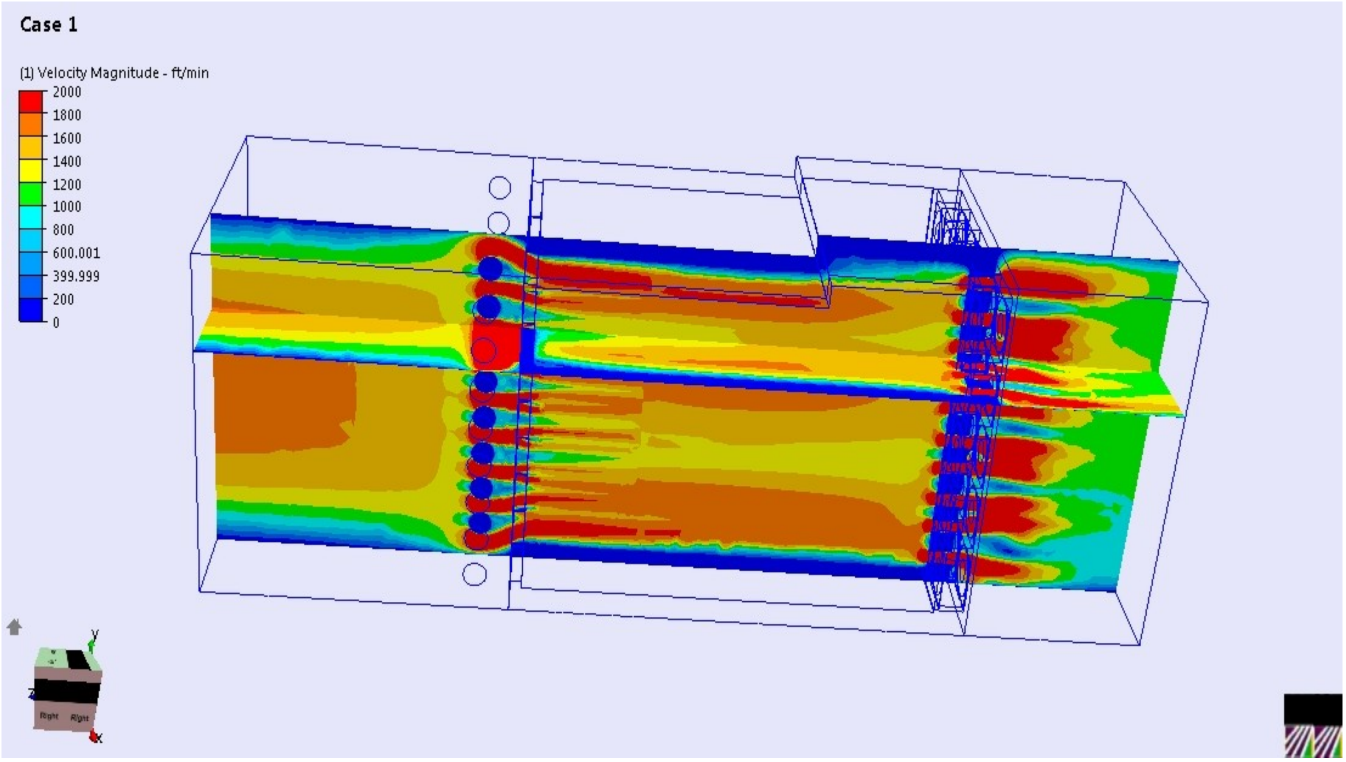


Figure 7, Cylindrical Cable bundles - Side View

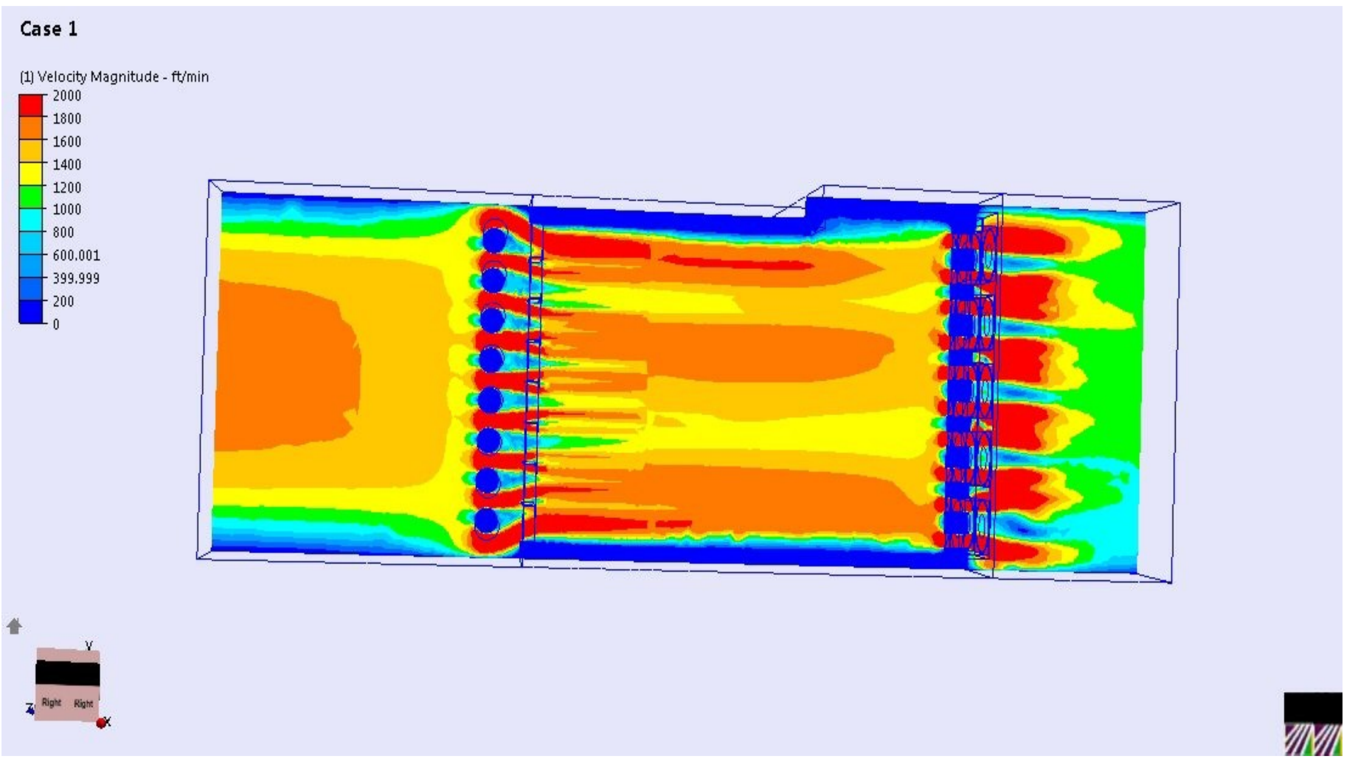


Figure 8, Flat Cable Bundles - 3D View

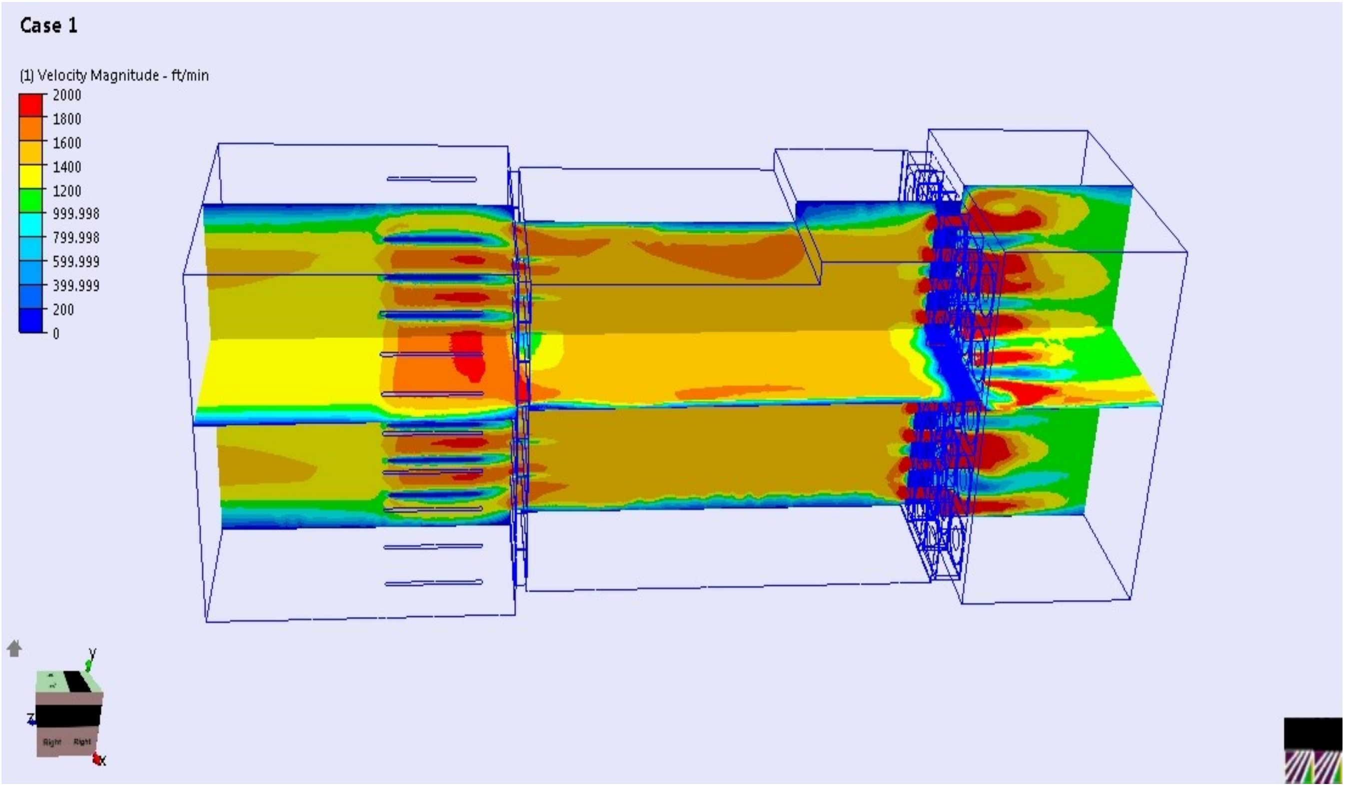
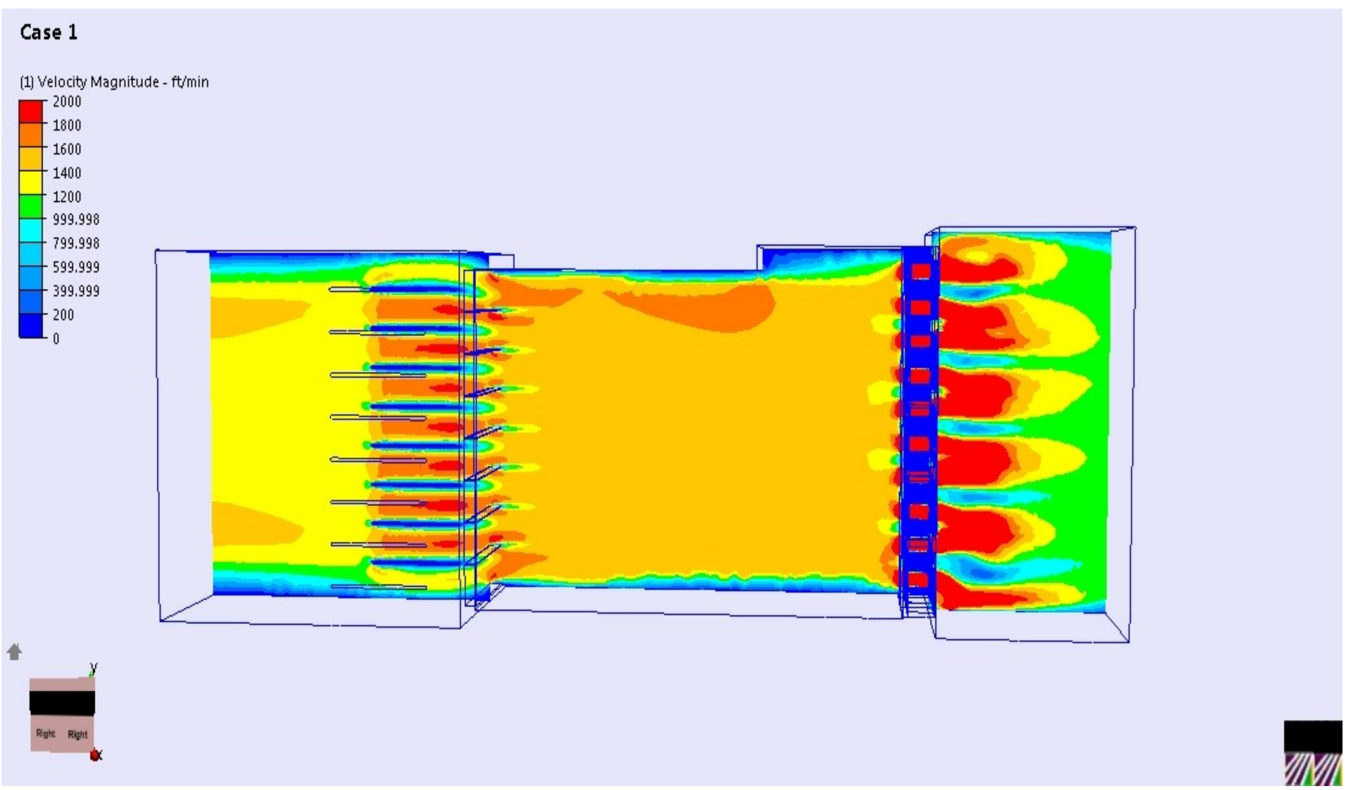


Figure 9, Flat Cable Bundles - Side View



Fan Performance Results

The fan performance results are provided as graphical plots of the static pressure in inches water column and volumetric flow in cubic feet per minute along with the manufacturers fan performance curve for the particular fan parameters input into the CFDesign code. These plots include the complete array of 25 fans operating in parallel and simultaneously for each of the three design configurations analyzed.

Figure 10, No Cable Bundles

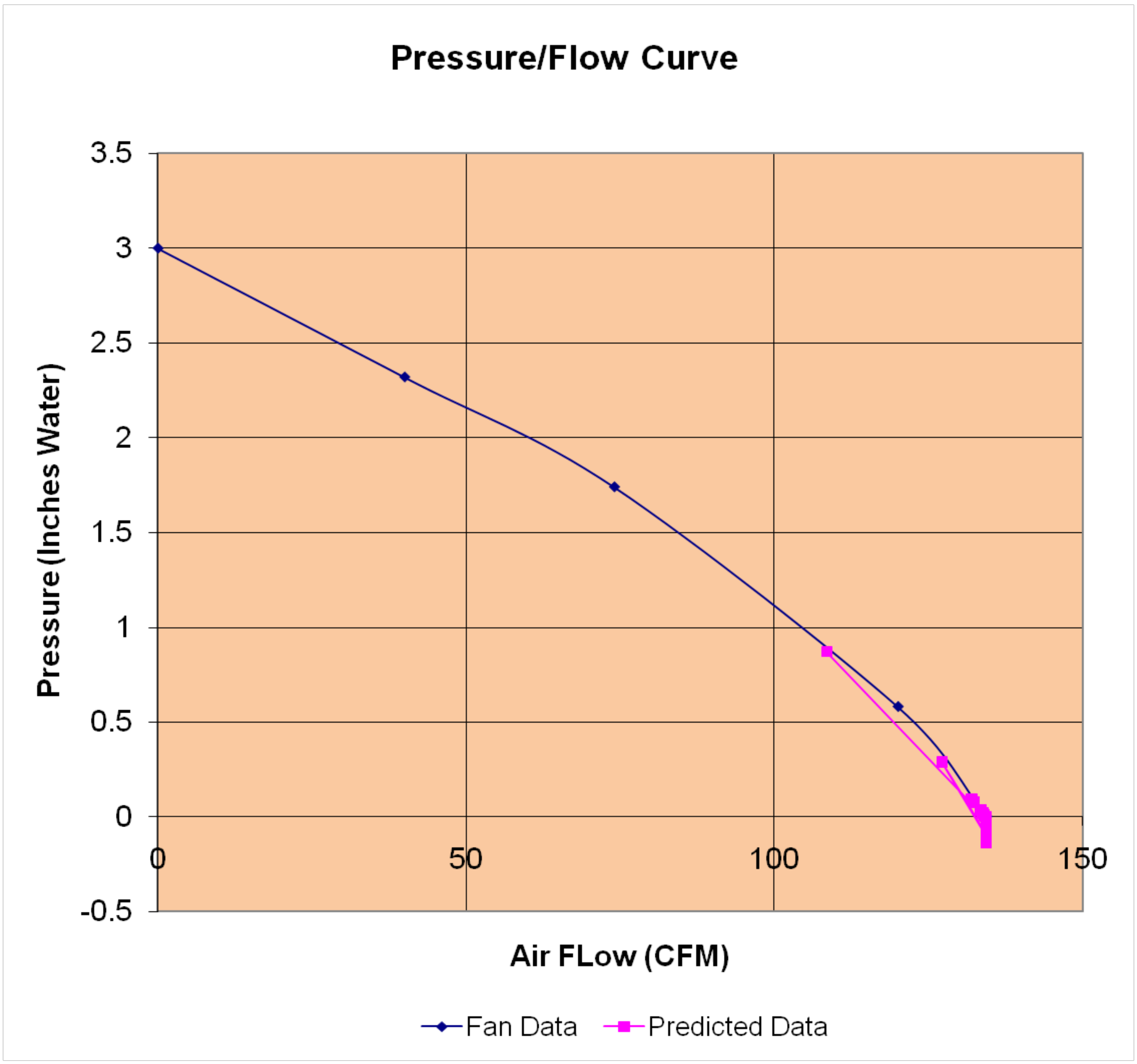


Figure 11, Cylindrical Cable Bundles

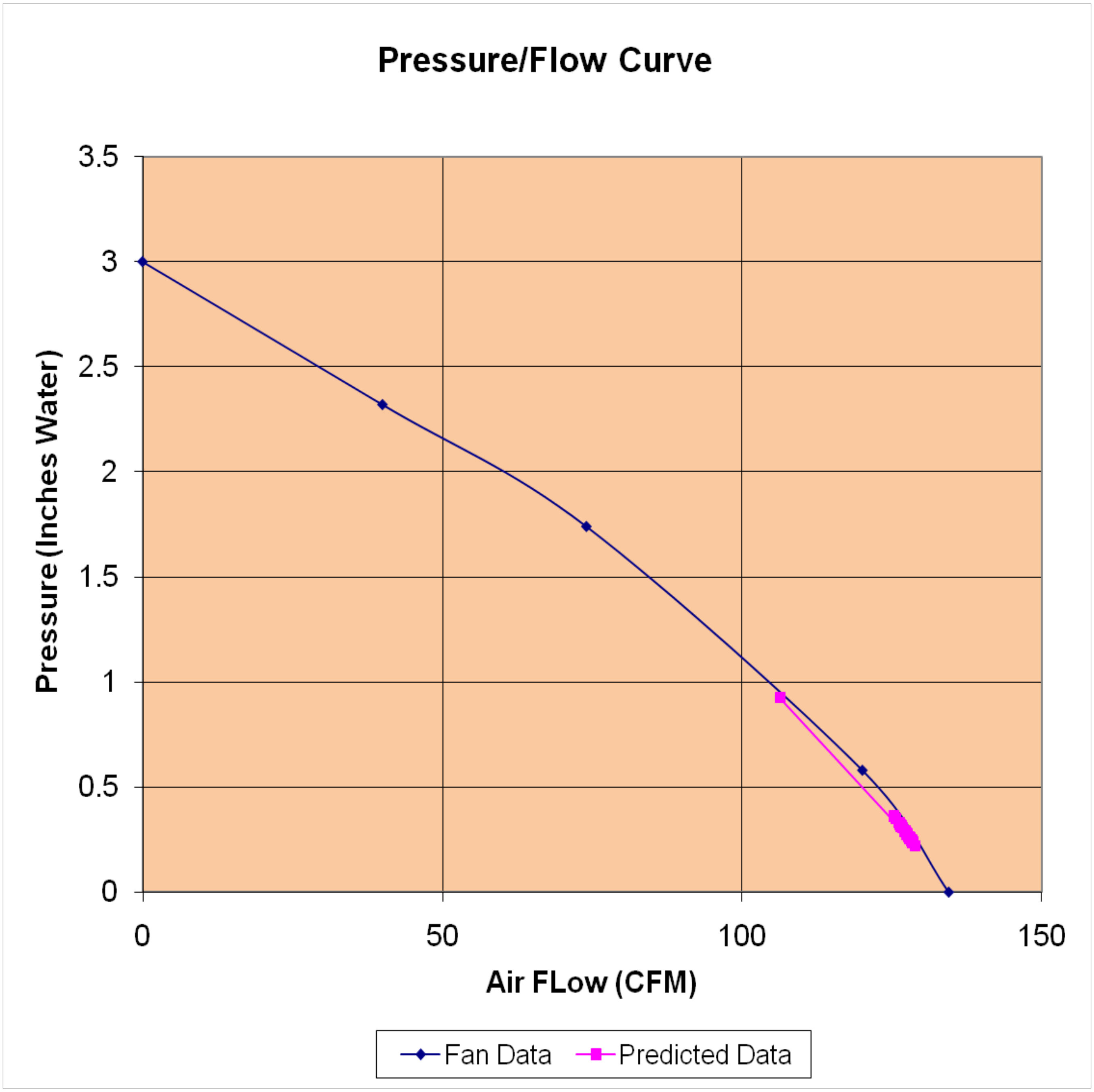


Figure 12, Flat Cable Bundles

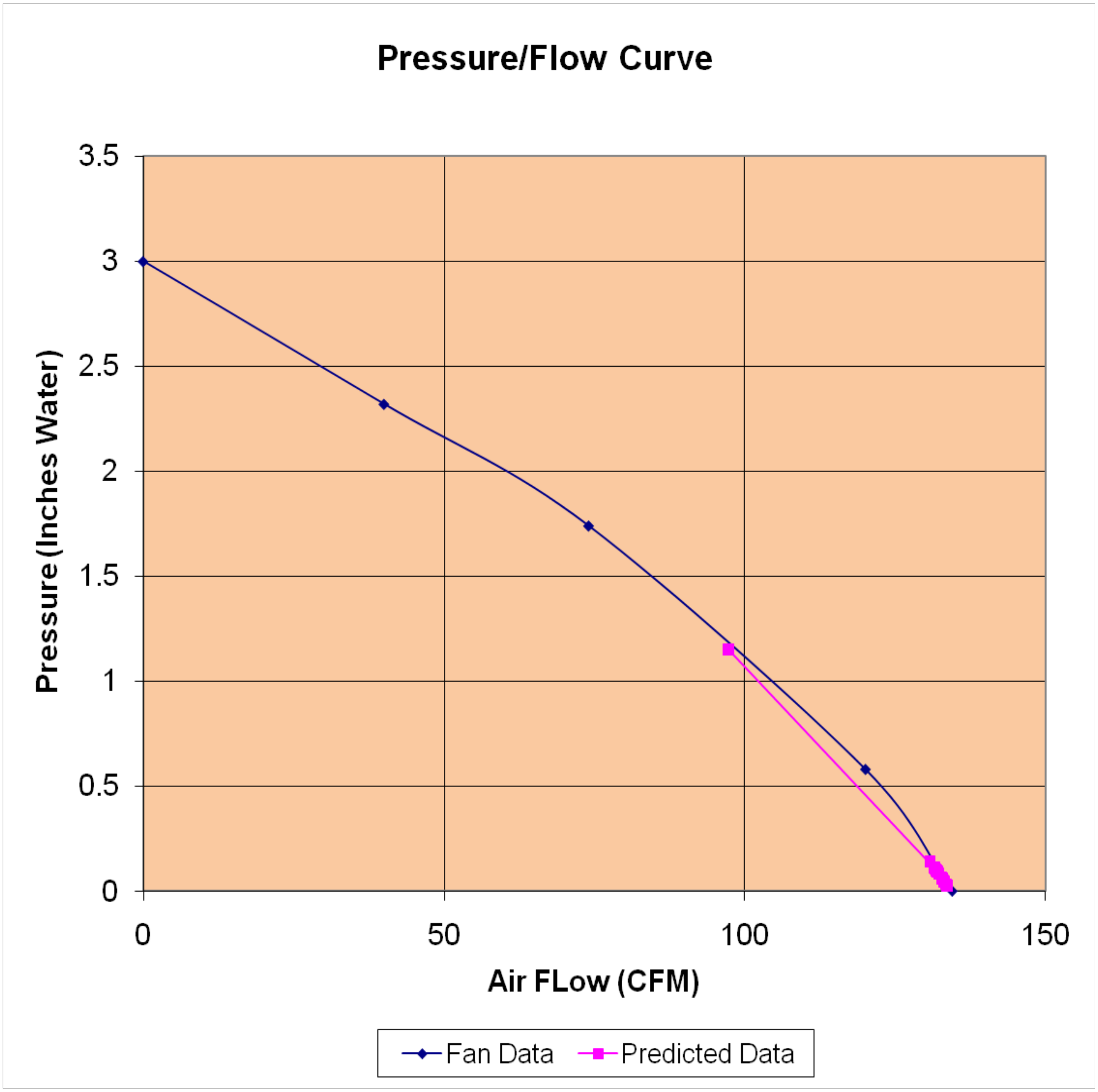


Figure 13, Air Flow Comparison

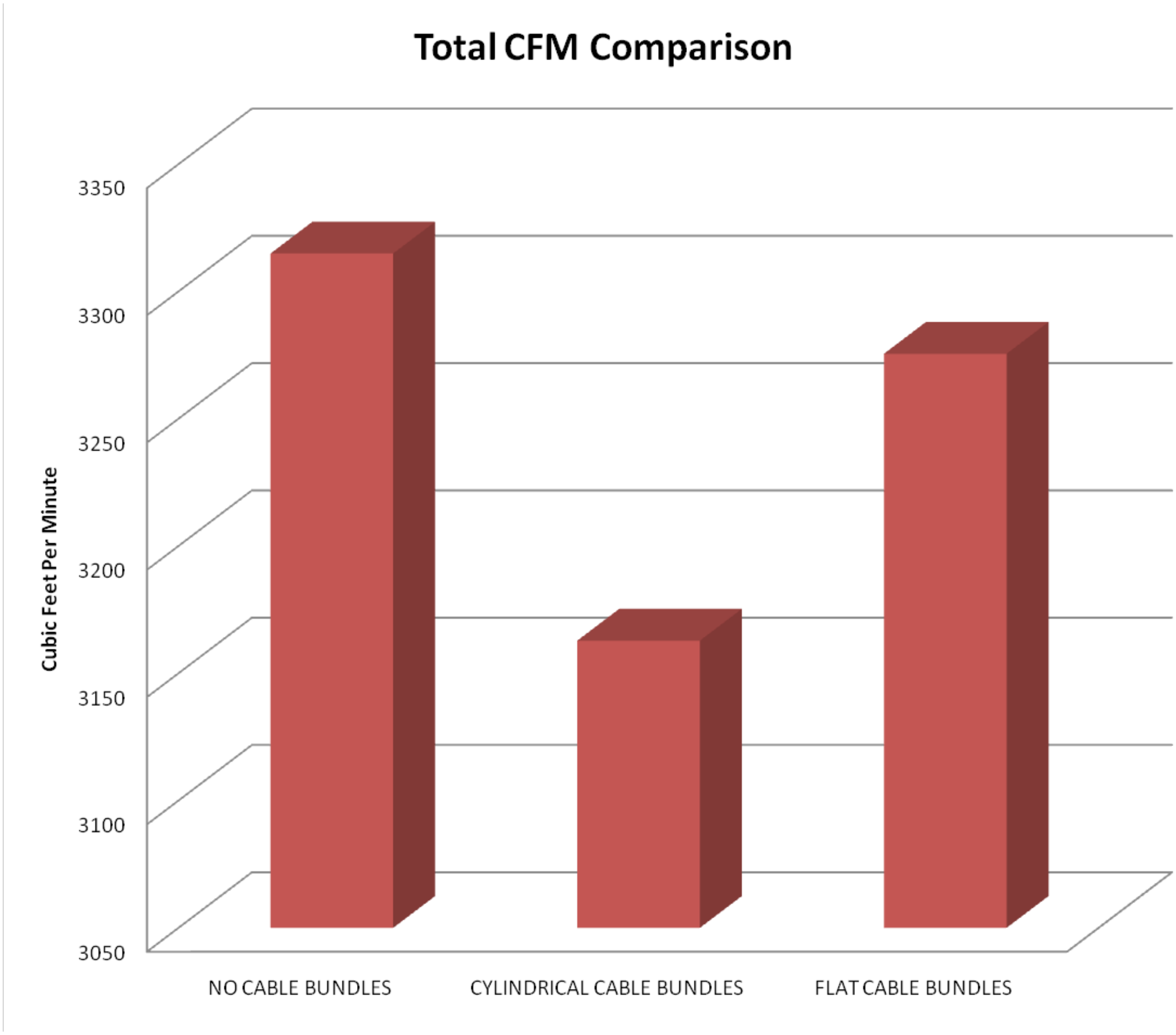
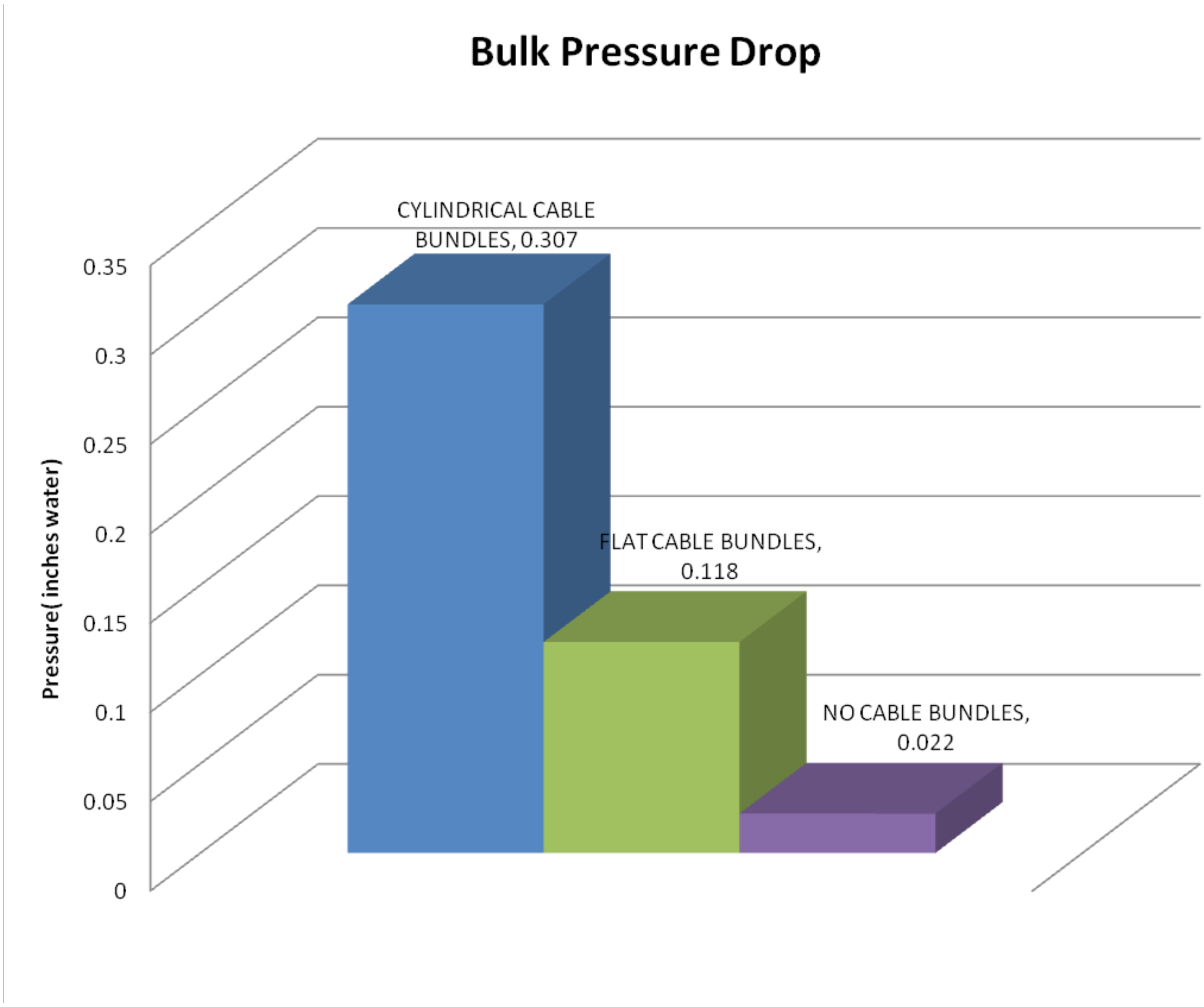


Figure 14, Bulk Pressure Drop Comparison



Conclusion

From review of the results of this analysis the cylindrical cable bundles provide higher internal velocities and slightly higher associated heat transfer coefficients[3] because the air must accelerate around the cylinder before entering the enclosure[4]. This acceleration results in higher velocities (1600 to 1800 ft./min.) within the electronic enclosure as can be seen in Figure 7. This compares to the velocities of 1400 to 1600 ft./min. in the no cable or flat cable bundle configurations. The increase in velocities comes at the expense of slightly lower total CFM through put of 100 to 150 CFM as compared to the flat cable bundles and no cable bundles, respectively as shown in Figures 13 and 14.

References

[1]
David S. Steinberg, "Cooling Techniques for Electronic Equipment," John Wiley & Sons, 1980.

[2]
Gordon N. Ellison, "Thermal Computations for Electronic Equipment," Van Nostrand Reinhold Company, 1984.

[3]
W. M. Kays and M. E. Crawford, "Convective Heat and Mass Transfer," McGraw-Hill Book Company, 1980.

[4]
Frank M. White, "Fluid Mechanics," McGraw-Hill Book Company, 1979.