HPC Data-Center Cooling Performance and Design

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***Abstract*—Cooling performance and design in a data-center are critical to its successful operation. There are many contributing factors to the efficiency and effectiveness of the cooling in data centers, both in the design phase and in the post-analysis to determine and improve performance. The visualization covers the Holland Computing Center's (HCC) data-center cooling design and various ways cooling is affected.**

***Index Terms*—data-center, CFD, computational fluid dynamics, data-center design, cooling, HCC, Holland Computing Center**

I. Introduction

HCC's Schorr data-center contains 35 racks of machines with three Computer Room Air Conditioner (CRAC) units using two cold-aisles and a single hot aisle. The initial idea for the analysis and visualization started with wanting to visualize and improve the airflow in the server room. Initially, testing began with mostly sealing the hot aisle in using insulation foam to force air into the ceiling for return to the CRAC units, rather than out into the room from the hot aisle. This test showed no significant results when temperatures were measured from the machines, but infrastructure items reported fewer issues. The project transitioned to Computational Fluid Dynamics (CFD) to analyze the results of what would occur with changes and to design and test different configurations rapidly.

II. Design

A. Goals and Objectives

- Visualize airflow of the current data center structure
- Visualize airflow of the prior structure and modifications
- Compare designs to optimize airflow and cooling performance of the data-center in a simulation environment.

B. Modeling and Parameters

The 3D geometry was designed in Autodesk's Fusion 360 software using measurements of the data-center and its hardware to create a broad analysis of the environment.

1) Layout: The data-center layout used by HCC is primarily a row-oriented layout for the majority of nodes with five racks cooled in a room-oriented layout. On the north, east, and west walls are the three CRAC units.

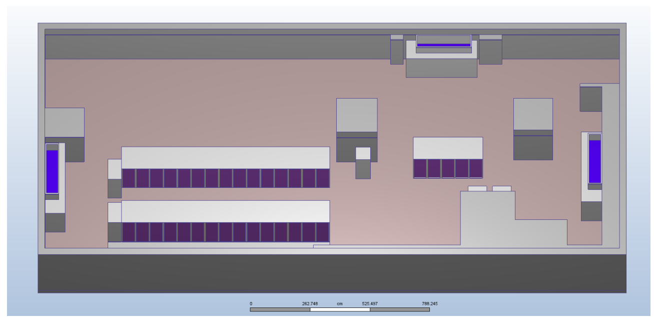

Fig. 1. Model of the base design

2) CRAC Units: The CRAC units have a measured output of 14200 to 15900 ft^3/min with a set-point of 60.1 degrees Fahrenheit, and report the fluid temperatures and air temperatures and provide a basis on conditions for cooling. The units supply the air into the raised floor of the machine room into the cold aisles. The hot air is then returned through the ceiling and cycled through the CRACs.

3) Racks: The racks were set to output approximately 800 ft^3/min of airflow [1].

4) Design Tests: There were four main designs tested and visualized based on both actual designs of the data-center and minor modifications.

- Original layout from 2018.
- Original layout with foam boards.
- Current layout.
- Current layout with foam boards.

C. Simulation Design

The model and parameters were then imported into Autodesk's CFD 2020 software to run simulations on different changes in the environment, starting with the base layout where the air is not guided to the ceiling, and only the racks and pressure control the primary path. The foam boards were added virtually, both for only the ends of the aisle and full containment.

The results were then saved and later analyzed. The analysis looked at the shifts in airflow from each of the different designs. The regions focused on were the ends of the hot aisle and the current version, where the five racks were removed.

III. Results

A. Base Design

With the original design of the data center, the expected result of airflow escaping from the east and west ends of the hot aisle occurred. This leads to air from the hot aisle being re-dispersed into the ambient environment and thus would cause the inlet temperature to increase on worker nodes and less effective cooling overall.

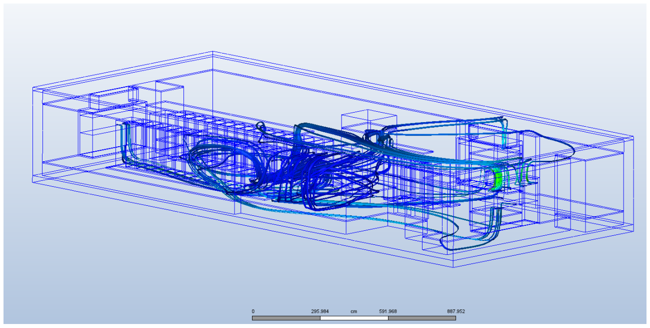

Fig. 2. Model of the base design, highlighting the recirculating airflow

B. Base design with ends and ceiling sealed with foam

The addition of foam boards to encase the hot aisle on both ends and the space between the top of the racks and the ceiling forced the exhaust air entirely into the ceiling and thus into the return of the CRAC units. This is an improvement overall from the prior design as none of the exhaust air from the two rows is escaping into the environment.

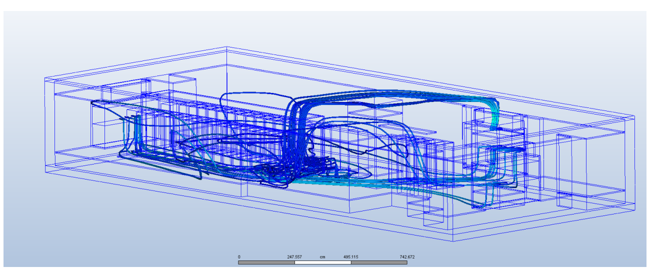

Fig. 3. Model of the base design, highlighting the recirculating airflow

C. Adjustment to current design

In 2018, the data-center structure underwent a change in design where five racks were moved to another cluster, thus changing the layout drastically. This allowed more of the air from the hot aisle to flow out into the northern cold aisle. The change allowed more opportunity for cold air to be introduced into the hot aisle and be returned. The extra pressure helped contain the return air in the hot aisle on the east side of the room.

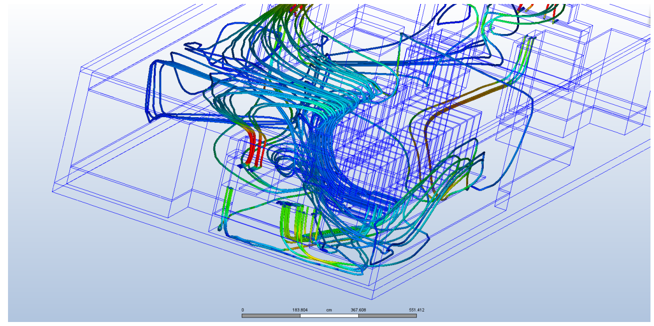

Fig. 4. Model of the base design, highlighting the recirculating airflow

D. Current design with ends and ceiling sealed with foam

The addition of the foam board barriers created a similar airflow pattern to the base design's addition of foam boards and similar benefits. In theory, this creates the largest thermal delta between the exhaust and return air from the worker nodes and the temperature of the chilled water in the CRAC units, creating a more efficient heat transfer.

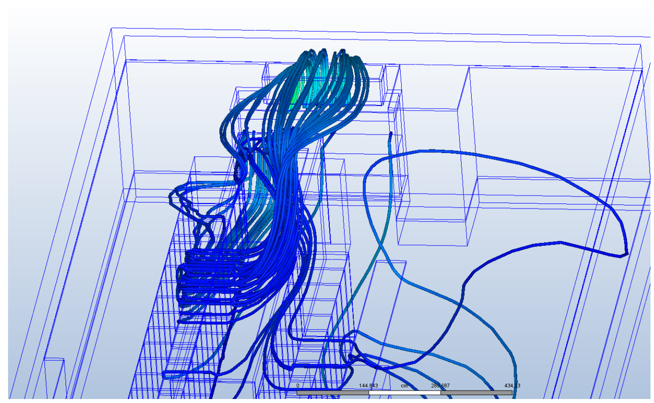

Fig. 5. Model of the base design, highlighting the recirculating airflow

IV. Acknowledgements

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References

[1] Autodesk. "09.03_Data Center_Exercise_Part-1" Autodesk. https://knowledge.autodesk.com/support/cfd/learn-explore/caas/simplecontent/content/0903data-centerexercisepart-1.html (accessed June 2020)