



Modelling Temperature Distribution Analysis in a Data Center Using CFD-Transient Analysis for Cooling Layout Optimization

S.P.N.C. Croos^{1}, S. Sharan¹, Y.M.U.I. Yapa¹, V.H.P. Vitharana¹*

¹ Department of Engineering Technology, Faculty of Technology, University of Ruhuna, Sri Lanka

**Corresponding author: hashini@fot.ruh.ac.lk*

A data center is a specialized facility that houses computer systems, servers, storage devices, and associated networking equipment, where energy efficiency is crucial due to high overall energy consumption. The improvement of cooling system efficiency represents a great opportunity for energy and cost savings in a data center. Computational Fluid Dynamics (CFD) is an effective tool that provides a platform for analyzing airflow patterns and thermal behavior in data centers, for both existing and proposed configurations, before they are built. This study presents a computational fluid dynamics (CFD)-transient analysis aimed at identifying an efficient and optimized cooling layout for an air-cooled data center using ANSYS Fluent software. A three-dimensional (3D) model of a raised-floor data center is developed, and eight cooling layout configurations are investigated: four configurations with a single air-conditioning unit (ACU) and the same four configurations with dual ACUs. For each layout, airflow patterns and temperature distributions are analyzed in terms of rack inlet temperature, hot-spot formation, and ACU net cooling power. The simulation results provide detailed three-dimensional temperature and velocity fields and demonstrate how ACU number, positioning, and airflow organization influence the thermal performance of the data center. By comparing the eight cases, the study identifies the layout configurations that most effectively reduce hot spots and maintain inlet and outlet temperatures within the allowable ranges recommended by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standards. The results indicate that the most efficient configuration for a data center equipped with a single ACU is achieved with the ACU located on the front wall side, yielding a temperature of 20.12°C under the cold aisle arrangement. For the dual-ACU configuration, the most efficient layout is obtained with ACUs placed on adjacent walls, resulting in a temperature of 19.09°C under the hot aisle arrangement.

Keywords: Air-conditioning unit (ACU) layout, Inlet outlet air temperature optimization, Raised-floor air distribution