High Density Data Center Cooling

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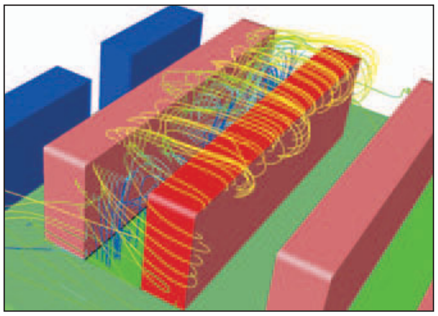
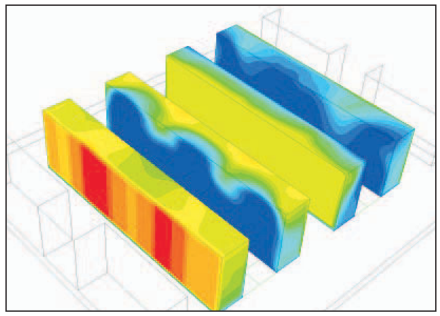
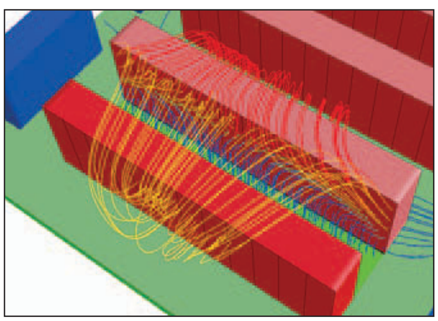


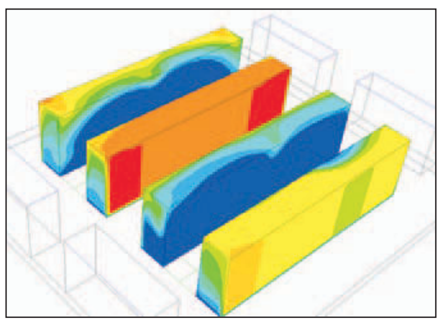
Pathlines, colored by temperature, for the parallel rack orientation showing the recirculation of hot air into the cold aisle; the high density rack is shown in red



Temperatures on the rack surfaces for the parallel orientation, showing the excessive heating of the upper portion of the low density rack, left, resulting from the entrainment of heated air from the high density rack, second from left



Pathlines, colored by temperature, for the perpendicular rack orientation showing the entrainment of hot air from two hot aisles into the cold aisle between them; the high density rack is shown in red



Temperature on the rack surfaces for the perpendicular orientation, showing the impact of the entrained hot air on the surface temperature of the upper servers facing the cold aisle

As the computational power of servers increases, so does the heat load associated with them. Air conditioning systems that were the norm for data centers of the recent past can now no longer handle the increased load. As new data centers come on-line or existing data centers are upgraded, improved air conditioning methods are now mandatory. The problem isn't that sufficient air conditioning cannot be provided, but that the air conditioning must be provided where it is needed. This means that the flow characteristics of the air stream that provides the cooling must be carefully studied as the air progresses from the computer room air conditioner (CRAC), through the racks of equipment, and back to the CRAC.

Facilities Engineering Associates (FEA), in conjunction with Fluent, has recently completed an analysis of a representative data center. The room contains four racks of computers and four CRACs, located in pairs at opposite ends of the room. In addition to the main floor, an elevated floor, 14 inches above the main floor, is used to support the racks. The data center is laid out with a hot-aisle / cold-aisle arrangement by careful positioning of the racks and perforated sections in the elevated floor. The CRACs dispense cooling air under the elevated floor. This air rises through the perforated sections, forming cold aisles. The cold air flows through the racks where it picks up heat before exiting from the rear of the racks. The warm exit air forms hot aisles behind the racks, and the hot air returns to the CRAC intakes, which are positioned above the floor. Two orientations for the data center were studied – one with the racks (and perforated flooring) parallel to the CRACs, and the other with a perpendicular orientation. For both cases, one server rack (shown in red, far left) was assumed to have a higher (about 2.5 times) power density rating than the others.

Pathlines colored by temperature were used to show the progression of the air streams from the perforated flooring, through the racks, and back to the CRAC units for the two configurations studied. Both designs were found to be problematic as a result of the high-density rack in the room. For the parallel orientation, hot air exiting from the high-density rack circles over the top of the rack and reenters the cold aisle, where it is drawn into the servers located in the upper section of the neighboring low-density rack. The lower portion of the low-density rack is properly cooled by air entering through the floor tiles. For the perpedicular orientation case, a similar problem occurs: hot air exiting not only from the high-density rack but also from the adjacent low density rack circles above and around the sides of the rack and reenters the cold aisle, compromising the cooling air that is delivered through the floor tiles. A display of the temperatures on the surfaces of the racks indicates that while the high density rack is adequately cooled for both cases, the neighboring racks are not.

By using CFD in its design process, FEA identified the potential cooling problems before they occurred, thereby saving the time and expense required for repairs or retrofitting once the construction of the room is complete and the room is operational. ■

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