LOW ENERGY COOLING OF ROOMS WITH DISPLACEMENT VENTILATION

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In recent years, energy efficient and chemical free cooling based on displacement ventilation systems have gained considerable popularity in removal of heat loads from large industrial spaces and office buildings. Here in this study, somewhat similar heat transfer analysis is made for rooms with not so large dimensions. For this purpose, a transient heat transfer problem involving conduction, convection and radiation is solved numerically with a commercial code using the Finite Volume technique. The turbulence modeling[1] is also considered for predicting the turbulence level of the flow in the room.

The problem solved here is the transient cooling of a room with a chilled ceiling, a hot and a cold side walls and with an insolated floor. The floor size is 4x4 meters and the maximum height is 2.85 meters. The 3-D grid inside the room is shown in Fig.1, where altogether 109,000 cells and 116,653 grid points are used and, where x-y plane is the symmetry plane on which the symmetry conditions prevail. The cool air is blown towards the ceiling from the slit on the top of the cold wall and the hot air comes out from the bottom of the hot wall. The velocity field on the symmetry plane is shown in Figure 2. For 1 m/s inflow velocity results, shown in Figure 3 is the turbulence intensity contours on the symmetry plane. As desired[2] the highest intensities in the room is less than 5%. The symmetry plane temperature contours obtained with k-ε turbulence modeling are depicted in Fig 4. The temperatures are given in Kelvin and as expected after cooling the average room temperature is almost 3 degrees less than the average initial room temperature. The initial room temperature is linear between the cold and the hot wall and the inflow air and the chilled ceiling temperature is 3 degrees less than the cold wall temperature. The steady state is reached at around 500 seconds. The blow rate is 30 liters per second.

The full paper will cover i) more parametric studies, and ii) results obtained with addition of a wing-like structure under the ceiling to increase the rate of circulation of the blown air.

REFERENCES

1. Launder, B.E. and Spalding, D.B., *Lectures in mathematical Models of Turbulence*, Academic Press, London, England, 1972.
2. Levermore, G.J., *Building Energy Management Systems*, E&FN Spon, London, England, 2000.

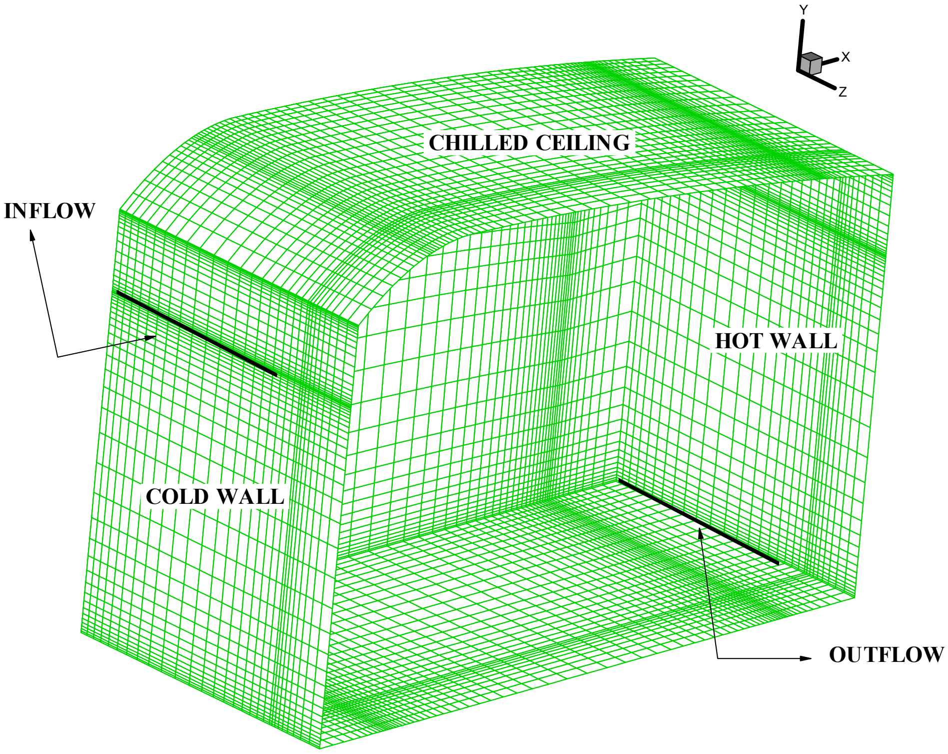

Figure 1: The grid structure and boundary conditions for the room.

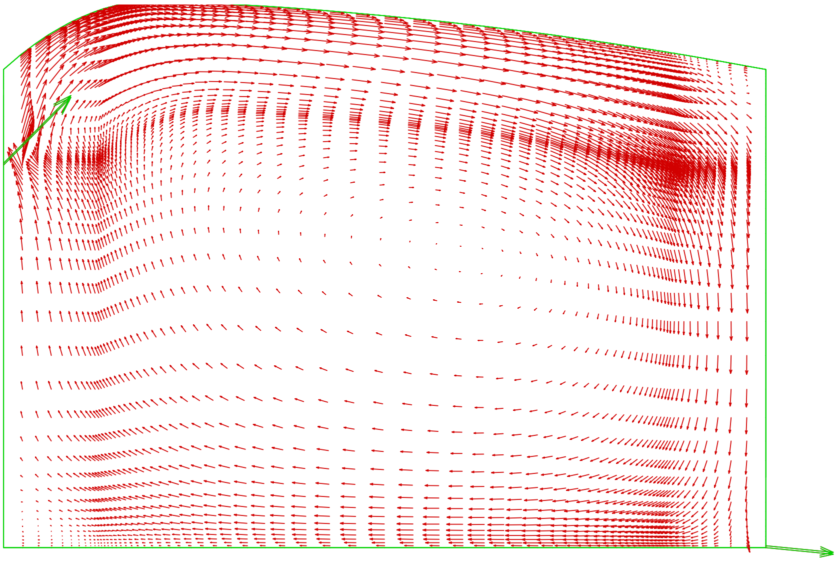

Figure 2: Symmetry plane velocity vector field for time t=500 sec.

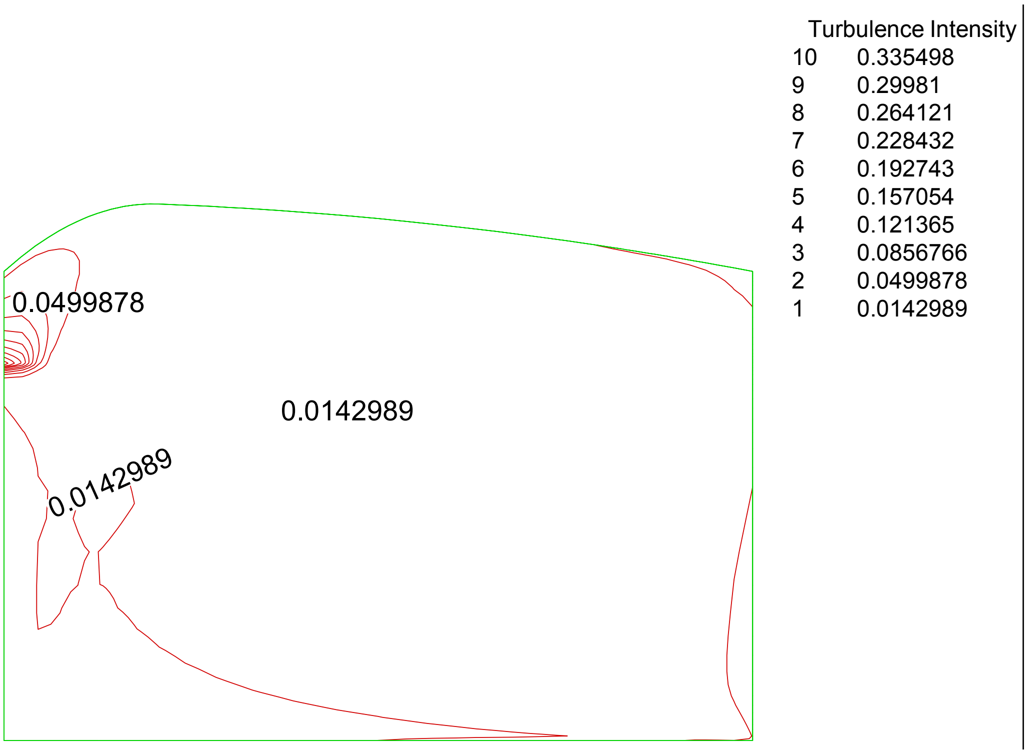

Figure 3:Symmetry plane turbulence intensity contours for time t=500 sec.

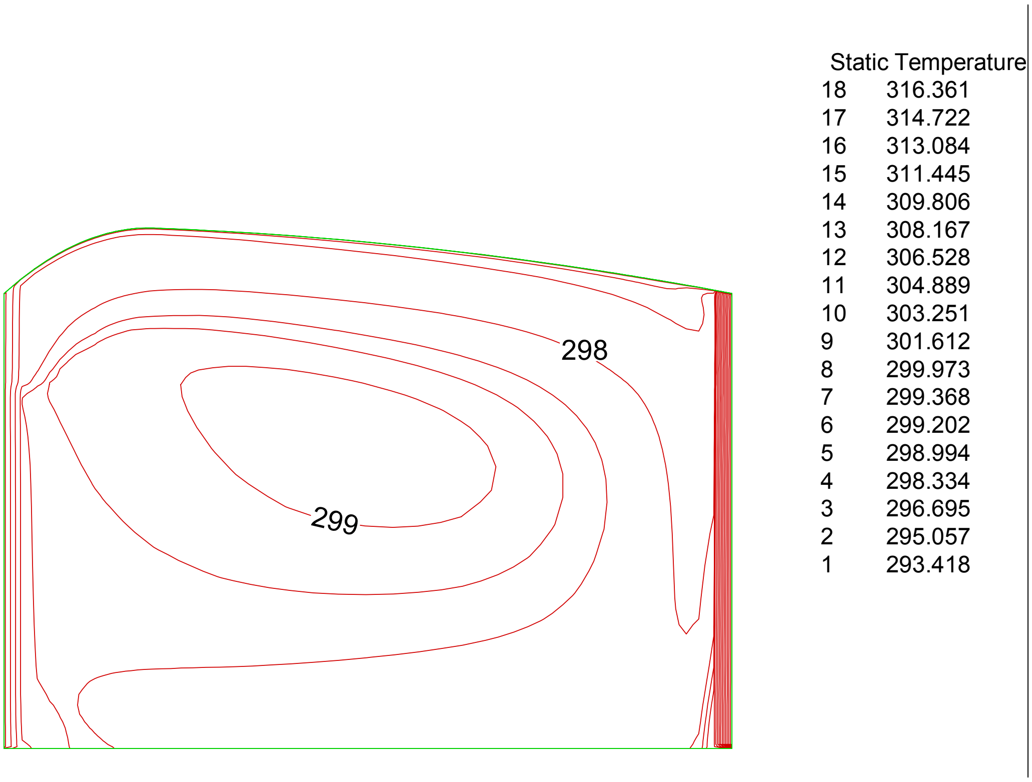

Figure 4: Symmetry plane temperature (in Kelvin) contours in k-ε turbulence model for inflow velocity 1 m/sec and time t=500 sec.