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Turbulent natural convection combined with surface thermal radiation in a square cavity with local heater

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Abstract
Purpose: The purpose of this paper is to conduct a numerical analysis of transient turbulent natural convection combined with surface thermal radiation in a square cavity with a local heater. Design/methodology/approach: The domain of interest includes the air-filled cavity with cold vertical walls, adiabatic horizontal walls and isothermal heater located on the bottom cavity wall. It is assumed in the analysis that the thermophysical properties of the fluid are independent of temperature and the flow is turbulent. Surface thermal radiation is considered for more accurate analysis of the complex heat transfer inside the cavity. The governing equations have been discretized using the finite difference method with the non-uniform grid on the basis of the special algebraic transformation. Turbulence was modeled using the k–ε model. Simulations have been carried out for different values of the Rayleigh number, surface emissivity and location of the heater. Findings: It has been found that the presence of surface radiation leads to both an increase in the average total Nusselt number and intensive cooling of such type of system. A significant intensification of convective flow was also observed owing to an increase in the Rayleigh number. It should be noted that a displacement of the heater from central part of the bottom wall leads to significant modification of the thermal plume and flow pattern inside the cavity. Originality/value: An efficient numerical technique has been developed to solve this problem. The originality of this work is to analyze unsteady turbulent natural convection combined with surface thermal radiation in a square air-filled cavity in the presence of a local isothermal heater. The results would benefit scientists and engineers to become familiar with the analysis of turbulent convective–radiative heat transfer in enclosures with local heaters, and the way to predict the heat transfer rate in advanced technical systems, in industrial sectors including transportation, power generation, chemical sectors and electronics. © 2018, Emerald Publishing Limited.

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