Influence of wall roughness and thermal conductivity on turbulent natural convection

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Abstract

We study turbulent natural convection in enclosures with conjugate heat transfer. The simplest way to increase the heat transfer in this flow is through rough surfaces. In numerical simulations often the constant temperature is assigned on the walls, but this is an unrealistic condition in laboratory experiments. Therefore, in the DNS, to be of help to experimentalists, it is necessary to solve the heat conduction in the solid walls together with the turbulent flow between the hot and the cold wall. Here the cold wall, $0.5h$ tick is smooth, and the hot wall has 2D and 3D rough elements of thickness $0.2h$ above a solid layer $0.3h$ tick. The simulation is performed in a bi-periodic domain $4h$ wide. The Rayleigh number varies from 10^6 to 10^8, two values of the thermal conductivity were chosen, one corresponding to copper and the other ten times higher. It has been found that the Nusselt number behaves as $Nu = \alpha Ra^{\gamma}$, with α increasing with the solid conductivity and it depends of the roughness shape, and 3D elements produce a greater heat transfer than 2D elements. An imprinting of the flow structures on the thermal field inside the walls is observed. The one-dimensional spectra at the center, one decade wide, agree with those of forced isotropic turbulence.

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