Enhancing the heat flux of turbulent convection by heterogeneous porous layer

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Abstract

Enhancing the heat flux of turbulent convection is highly desirable in many practical applications. In this talk, we propose a strategy to bypass the bottleneck of boundary layers for heat transfer by introducing two layers of porous medium adjacent to the top and bottom plates. Especially, the solid material for porous matrix has much higher thermal conductivity than that of working fluid, and porosity gradually decreases in the vertical direction from the plate to the fluid-porous-layer interfaces. We conducted numerical simulations for various Rayleigh number, Prandtl number, and thickness and conductivity of porous layer. The results reveal that the heat flux is considerably increased compared to the normal convection system. And the scaling exponent for Nusselt number exceeds the ultimate scaling of 1/2 when the Rayleigh number is high enough. Two mechanisms are responsible for the enhancement. Namely, the high conductivity of poroius matrix can efficiently transfer heat from plates into the domain, and the relatively low porosity close to the fluid-porous-layer interace allows the penetration of large-scale convection rolls into the porous layer which efficently transport heat across different layers. The strategy propsoed here can be realized by using metalic foam with the aid of 3d printing techniques.

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