Rayleigh–Bénard Convection in a cylinder with axi-symmetry assumption

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1.INTRODUCTION & OBJECTIVE

Two-dimensional Rayleigh–Bénard Convection in a very shallow cylindrical enclosure has been the subject of research interest amongst scientists, engineers and technologists for some time now due to its applications involving non-isothermal fluid systems. To make the problem analytically tractable, most researchers make use of the unrealistic free-free isothermal boundaries which serve the purpose of qualitatively predicting the eigenvalue of the problem([1], [2], [3], [4], [5] and references therein). The use of the artificial boundaries facilitated analytical procedures which is no longer the case when one considers realistic boundary conditions. It is the latter boundary conditions that we consider in the paper and hence we adapt a fifteen-term power-series solution for the eigenfunctions which ensures an accuracy of 10^{-4} in the estimation of the eigenvalue. The results of the rigid-rigid boundaries are compared with those of free-free. It was found that the critical eigenvalue of the rigid-rigid boundary combination is greater than that of free-free boundaries. There is qualitative similarity between the results of cylindrical and rectangular Rayleigh–Bénard Convection.

2. RESULTS AND HIGHLIGHTS OF IMPORTANT POINTS

Axi-symmetric Rayleigh–Bénard convection in a very shallow cylinder with rigid walls is studied to determine the onset of convection for the flow pattern of longitudinal rolls. A combination of Galerkin and power-series expansion is used together with the Newton-Raphson method to get an estimate of the critical Rayleigh number and the critical wave number. The critical Rayleigh number of the rigid boundary case is found to be larger than that of free boundaries. Isothermal boundary condition is used on temperature.

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