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The Influence of Mechanical Vibrations on Buoyancy Induced Convection in Porous Media

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8.1 Introduction

8.1.1 Definition

Natural convection is a fluid flow mechanism in which the convective motion is produced by the density difference in a fluid subjected to a body force. This difference is usually caused by thermal and/or chemical species diffusion. Consequently, to obtain natural convection, two necessary conditions should be satisfied; the existence of a density variation within a fluid and the existence of a body force. Some common examples of body forces include gravitational, centrifugal, and electromagnetic forces, which may be constant, like gravitational force or may exhibit spatial variation as in centrifugal force. It should be noted that the existence of the body force and the density variation do not guarantee the appearance of convective motion. The relative orientation of the density gradient to the body force provides the sufficient condition for the onset of convection.

The possibility of controling the hydrodynamic stability of flows by modulation has attracted the attention of researchers for many years [1]. Two types of modulations have been extensively studied; the temperature modulation and the gravity modulation. It is shown that by proper selection of the modulation parameters, dramatic modification in the stability behavior of the dynamic system can be observed [2].

In some applications, it may be desirable to operate at Rayleigh numbers higher than the critical one at which the convection occurs and yet have no convection. Also it is advantageous to suppress undesired chaotic motions in order to remove temperature oscillations which may exceed safe operational conditions. In the context of the temperature or heat flux modulation in porous media, we may mention the study of Caltagirone [3] and of Rees [4], Rudariah and Malashetty [5] in the Rayleigh–Bénard configuration by temperature modulation and Antohe and Lage [6] in a square cavity heated laterally by flux modulation. Thermo-vibrational convection belongs to a special class of periodic flows in which the buoyancy force is time dependent. In this class, which is different from the problems concerning spatial variations of body forces [7–9], the action of external force field

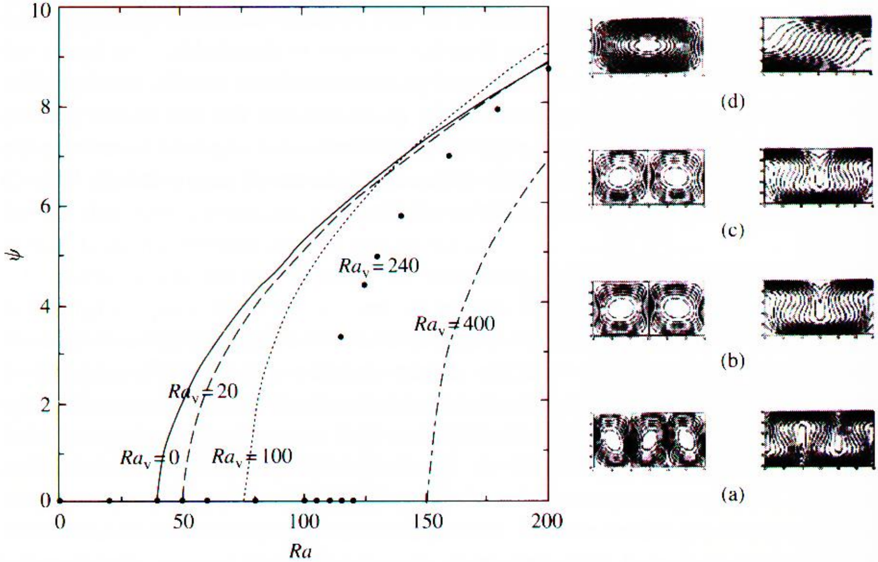

FIGURE 8.1
Bifurcation diagram in the ψ–Ra plane for different values of vibrational Rayleigh number. (From G. Bardan and A. Mojtabi. *Phys. Fluids* 12: 1–9, 2000. With permission.)