Sufficient Conditions for Stability of the Bernard Problem in Arbitrary Geometries

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Recently Catton and Edwards (*1*) and Davis (*2*) have used linearized stability analyses to find necessary conditions for stability of Newtonian fluids heated from below and contained in right circular cylinders or three-dimensional boxes, respectively. We wish to point out that the energy method of stability analysis (*3*, *4*) can be used to prove that the sufficient conditions for stability coincide with the necessary conditions for stability for the geometries and boundary conditions considered in references *1* and *2*.

In fact, the energy method can be used to show that the necessary and sufficient conditions for stability coincide for arbitrary geometries if the following conditions are met (*3*):

1. The Boussinesq approximation is valid.
2. A stationary-state solution exists with a zero velocity and a temperature gradient that is linear, parallel to, and in the same direction as gravity.
3. The velocity perturbations satisfy either $V_j = 0$, or $V_i \cdot N_i = 0$, $V_j\, \partial V_j/\partial X_i\, N_i = 0$ at all finite boundaries.
4. The temperature perturbations satisfy the general equation $\partial T'/\partial X_i\, N_i + N_{Nu} T' = 0$ at all finite boundaries.
5. In any infinite directions the velocity and temperature perturbations are either periodic or decay asymptotically to zero. When these criteria are satisfied, the results obtained from a linear stability analysis with exchange of stabilities are necessary, and sufficient conditions for stability, and subcritical instabilities cannot occur.

NOTATION

N_{Nu} = Nusselt number
N_i = dimensionless outward directed normal
T' = dimensionless perturbation in temperature
V_j' = dimensionless perturbation in velocity
X_i = dimensionless general coordinate direction

LITERATURE CITED

1. Catton, I., and D. K. Edwards, *AIChE J.*, **16**, 594 (1970).
2. Davis, S. H., *J. Fluid Mech.*, **30**, 465 (1967).
3. Joseph, D. D., *Arch. Ratl. Mech. Anal.*, **20**, 59 (1965).
4. Shir, C. C., and D. D. Joseph, *Arch. Ratl. Mech. Anal.*, **30**, 38 (1968).

BOOKS

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comprehension by novices difficult. The names of authors of literature references are often misspelled and in some cases are indexed twice or not at all.

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Gas-Liquid Reactions, P. V. Danckwerts, McGraw-Hill Book Co., New York (1970). 276 pages. $11.50.

Gas-liquid absorption in both reacting and nonreacting systems has been the subject of numerous experimental and theoretical studies in the past twenty years. The author has been noteworthy among those who have applied our increased understanding of kinetics and mass transfer to the development of coherent models for the design of gas-liquid contacting apparatus.

This book summarizes the results of such advances both by his own group and by many others. As a clear presentation of the subject from basic principles to design of process units, the book represents a significant contribution to the chemical engineering literature. It is suitable as a text for a graduate course in mass transfer operations and will also be valuable as a reference for the practicing engineer, because of the clear exposition of underlying theory and because of the large number of practical examples.

Although not so designated by the author, the book falls into three sections. The first four chapters discuss the elements of diffusion and absorption into quiescent liquids with simultaneous reaction obeying various kinetic laws. The second section discusses absorption into agitated liquids, an area in which the author has made significant contributions. Finally, the last four chapters discuss absorption with reaction in process equipment.

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