TEMPERATURE INVERSION IN THE KINETIC THEORY OF EVAPORATION

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ABSTRACT

The singular-eigenfunction-expansion technique is applied to the problem of evaporation and condensation between parallel surfaces. "Critical" values of β, the slope of the saturated vapor density-temperature curve, are reported so that the condition for which the center-line slope of the temperature profile in the vapor will be in opposition to the imposed temperature gradient can readily be noted.

INTRODUCTION

A problem of recent interest to workers in the kinetic theory of gases is that of evaporation and condensation. Y. P. Pao [1,2], using mathematical tools provided by the Wiener-Hopf technique and the linearized single-relaxation model of the Boltzmann equation, considered the evaporation problems in a half space and between parallel surfaces. Siewert and Thomas [3] subsequently showed Pao's result [1] to be in error, and calculated very accurate results for the half-space problem through application of the singular-eigenfunction-expansion technique [4] to the same modeled Boltzmann equation. Quite recently, Cipolla, Lang, and Loyalka [5] used variation methods to achieve results in essential agreement with those of Siewert and Thomas [3].

The present work is concerned with an application of the analysis of Kriese, Chang, and Siewert [4], used in Refs. [3], [6], and [7], to the parallel-surfaces evaporation problem considered by Pao in Ref. [2]. Using this method, we have been able to confirm a rather novel prediction, made by Pao [2], concerning the shape of the temperature profile in the vapor, and to give explicit numerical values for the relevant results.

FORMULATION OF THE PROBLEM

We consider the problem of a vapor between two interphase (vapor-liquid or vapor-solid) surfaces maintained at $x=\pm d/2$; we assume that the condensed phase in $x<-d/2$ is kept at temperature

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