CONVECTIVE INSTABILITY IN ISOTHERMAL TERNARY GAS MIXTURES AT VARIOUS PRESSURES

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Abstract

An experimental study of the instability of mechanical equilibrium in gas systems 0.5994 H_2 (1) + 0.4006 Ar (2) – N_2 (3) and 0.8366 CH_4 (1) + 0.1634 R12 (2) – n-C_4H_{10} subject to the pressure is performed. It is shown that the stable diffusion process tends to unstable one and the intensity of convective flows increases by raising the pressure. Linear stability theory is applied to determine the boundary of transition from the state of diffusion to the region of the concentration convection. The experimental data are in good agreement with the theoretical results.
Keywords: diffusion, concentration gravitational convection, two-flask method, linear stability theory.

1. INTRODUCTION

The study of the liquid or gas movements is connected with the description of the various structural transformations. Almost any condition as the outer conditions change may experience structural transformations [1]. It is obvious that the existence of modes has a threshold character and the change of their state associated with certain values of the dimensionless parameters such as Reynolds numbers, Rayleigh, Mach, etc. The variety of modes of mixing increases significantly in the study of multicomponent systems. The intensity of mass transfer in such systems, as a rule, is determined by the molecular, convective, and often by co-action of these modes of [2]. However, practically does not take into account the fact that at the molecular diffusion can take place the instability of mechanical equilibrium of mixture, followed by the appearance of natural convection [3, 4], which significantly intensifies the overall mass transfer. Moreover, the emergence and development of the concentration of gravitational convection is possible not only in the frame work of traditional points of view (representations) of the thermal problem of Rayleigh-Bénard convection [1], but also for situations when the movement arise in stable stratification of the mixture. In multicomponent mixtures the instability of mechanical equilibrium is primarily dealt with the relations between multi-valued partial concentration gradients, and for the gas systems is fundamental and also essential the difference between the diffusion coefficients of components. Therefore, the study of the given issues related to the change of regimes "diffusion – convection" in multicomponent gas mixtures are important for the problems of convective heat mass transfer.

The paper presents experimental data for the study of convective mixing in isothermal ternary gas mixtures at different pressures. Computational model is proposed to determine the border regime change "diffusion – convection" in a vertical cylindrical channel of finite size. A comparison is carried out between the experimental and theoretical results.

2. EXPERIMENTAL STUDIES

In order to study the diffusion and convective transfer there was used the two flasks method [5, 6]. The analysis of the gas mixtures after mixing was carried out by chromatography method. The experiments were done in the pressure range from 0.1 to 4.0 MPa at temperature $T = (298.0 \pm 0.1)$ K. The lower bound of the pressure complied with the condition taken for analysis of a few samples, and the top – the technical features of the experimental devices.

Binary mixture of light and heavy in density components were in the upper flask. In the bottom flask was the gas, the partial density of which had an intermediate value. During all experiments at any compositions, pressure and temperature the binary mixture density was less than the density of gas in the bottom flask. The experimental method corresponds to the classical scheme. The experimental set