STUDY OF THE INTERACTION BETWEEN A LOW-PRESSURE GAS AND SURFACES OF POROUS BODIES DURING EVAPORATION

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Visual observations and film photography were used to determine the flow of the vapor–gas mixture near the surface of moist porous bodies of various shapes during heat and mass exchange.

The interaction pattern of transverse and longitudinal flows of a low-density gas was qualitatively studied in experiments which were made under ambient pressures of $6.5 \cdot 10^3$-$3 \cdot 10^2$ N/m^2; the flow pattern was made visible with the smoke technique.

The flow patterns around a round cylinder and a plate were studied. The bodies were situated parallel or perpendicular to the direction of the stream lines. The bodies, which had been made of a material with capillary porosity, were impregnated with a solution of hydrochloric acid (Figures 1 and 2a, b) and distilled water (Figure 2b). The smoke which was used to make the flow pattern visible was produced by introducing ammonia vapors into the gas in the chamber.

The smoke technique was used to display the flow pattern because this technique was simple to employ and allowed direct observations of the aerodynamic spectrum of the interacting flows. The entire process of producing and developing the vapor envelope on the surface of the bodies was recorded on film.

Density differences in the gas volume and a concentration gradient in the medium near the surface of evaporation, as well as a pressure gradient, were responsible for the motion of the ambient gas.

The overall direction of motion of the external flow was straight upward, and the flow velocity, which was determined from the film, amounted to 0.1-0.2 m/sec.

The visual observation method confirms that the intensity of the convective heat exchange in vacuum is strongly influenced by both the velocity and the density of the transverse mass flow. When the evaporation of moisture from a material having porous structure is intensive, the jet-like motion of the vapor from the surface of the body can be clearly recognized (Figure 1).

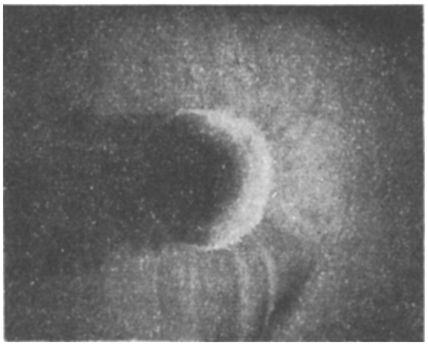

Fig. 1. Jet-like evaporation from a porous cylinder with a diameter of 40 mm.

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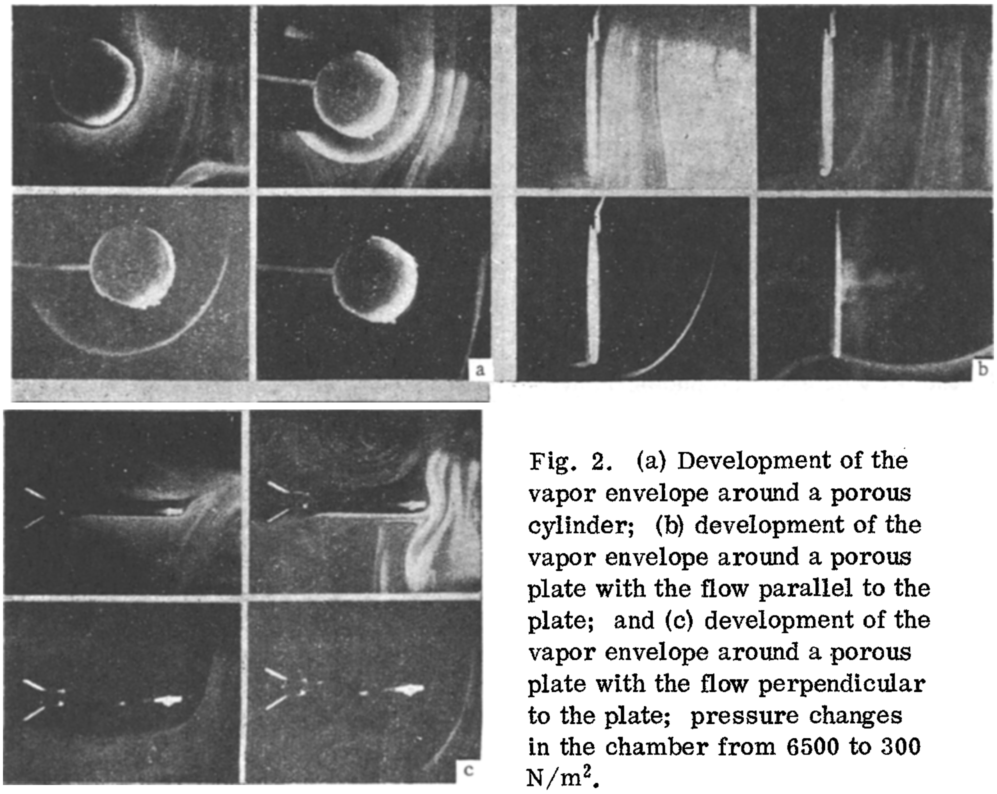

Fig. 2. (a) Development of the vapor envelope around a porous cylinder; (b) development of the vapor envelope around a porous plate with the flow parallel to the plate; and (c) development of the vapor envelope around a porous plate with the flow perpendicular to the plate; pressure changes in the chamber from 6500 to 300 N/m^2.

It was established by film photography that the individual jets of the transverse flow merge at a certain distance from the surface of the body and produce a vapor envelope which is characterized by a sharp interface with the external longitudinal flow. It was also observed that the vapor envelope disturbs the penetration of convective disturbances of the medium to the surface of evaporation. Energy is transferred into the evaporation zone primarily by molecular processes and by radiation.

Figure 2 depicts the flow around a cylinder and the flow around a plate which was placed perpendicular or parallel to the gas stream, which had a velocity of 0.1-0.2 m/sec; the total pressure in the medium was reduced from 6500 to 300 N/m^2. The intensity of evaporation from the cylinder (Figure 2a) was lower than that shown in Fig. 1, that the thickness of the vapor layer near the surface of the body was greatly reduced.

When the velocity of motion of the external flow is small, the thickness of the vapor envelope around the body increases with decreasing pressure in the chamber. At $P < 530\ N/m^2$, the envelope has a cross-sectional form of a circle, independent of the geometry of the body on a two-dimensional plane. Along with the increase in the envelope thickness, the interface line becomes smeared or disappears, and the same is true for the convective flow lines ($P < 260\ N/m^2$).

The studies of the interaction between the transverse and the longitudinal flows lead to the conclusion that the visible interface is a region of heat and mass exchange. The currents are mixed by diffusion in the area of the interface and temperatures and pressures are levelled in that area.