Parametric Pumping Separates Gas Phase Mixtures

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Parametric pumping, a dynamic adsorption process proposed by R. H. Wilhelm (*1*), has been used in the laboratory to separate the components of a binary gas-phase mixture. The preliminary results of an experimental investigation are presented in this paper.

A parametric pump is a device which couples an oscillating (in time) fluid-phase mass velocity with an oscillating fluid-phase–adsorbed-phase equilibrium relationship. The coupling is synchronized in such a manner that a driving force is produced to separate the components of the (binary) mixture.

MODEL

An idealized model (*2, 3*) of a closed-system pump is that of a series of stirred tanks. The system and the two parts of one operating cycle are illustrated in Figure 1.

The fluid and adsorbent phases have been separated in order to simplify the concept. Each segment or block may be considered as several (or one) stirred tanks in a series. The fluid phase is oscillated relative to the solid phase as indicated by positions I and II. The fraction of fluid in the bed that is displaced per oscillation has been arbitrarily chosen as one fourth. An operating cycle, if only one component of the binary mixture is assumed to be adsorbed, proceeds as follows. The system, initially in position I and with uniform concentrations in the fluid and adsorbed phases, is quickly transferred to position II. The temperature is decreased to T_{low} by an external means and the system allowed to approach equilibrium. The active component is adsorbed during this half of the cycle. In the second half of the cycle the system is rapidly transferred to position I, heated to T_{high}, and allowed to approach equilibrium. The active component is desorbed. A return to position II initiates another cycle. The net result of one complete cycle is the transfer of some of the active component from the right hand end to the left hand end of the system (Figure 1).

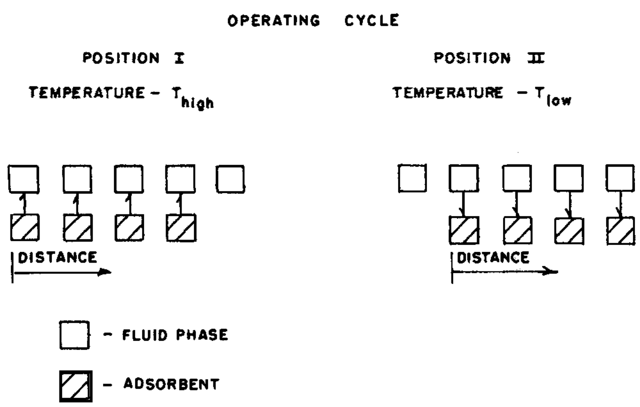

Fig. 1.

EXPERIMENTAL PROCEDURE

The materials chosen for the study were an equimolar ethane-propane mixture and an activated carbon adsorbent. Both components are adsorbed; however, the adsorbent exhibits a higher affinity for propane than for ethane. A closed-system–constant-volume apparatus was constructed to operate in a manner analogous to the model described. The gas mixture was pulsed back and forth through the tubular adsorbent bed by means of pistons located at each end of the bed. Heating and cooling were accomplished by alternately passing hot and cold water through a jacket surrounding the bed.

At the beginning of each experiment, the apparatus was first evacuated and then purged with the gas mixture until the adsorbed phase was of uniform concentration and in equilibrium with the equimolar ethane-propane purge gas. The system was then pulsed as described previously. The cycle time was two minutes and the process was continued through 60 cycles. Limiting condition concentrations at each end of the adsorbent bed were recorded. Vapor phase ethane concentrations of 36 and 67% are typical of the results obtained for any experiment.

DISCUSSION

The results of the experiments show that parametric pumping is applicable to vapor phase separations. The apparatus might be operated on a continuous flow basis by introducing feed in the middle of the bed and withdrawing product at the ends. It may also be considered as a single stage in a series, with operation as described by Wilhelm et al. (*1* to *3*).

It is of interest to note that a parametric separation can be accomplished by using any variable which alters the equilibrium relationship between the fluid and adsorbed phases. In regard to vapor phase applications this means that the pressure, rather than the temperature, can be used as the driven variable, thus eliminating the heat requirement inherent to thermal pumping.

ACKNOWLEDGMENT

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