§3. Estimation of Separative Performances of a Water-Distillation System for Recovery of Tritium

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From the view point of security of fusion reactor system, an amount of tritium released from the system to an environment must be reduced. A water distillation system is feasibly available to de-tritiation from water containing tritium as HTO, because the system can be operated safely and smoothly. A practical design of the system requires an establishment of a method for estimating separative performances. A purpose of the present study is to establish the analytical method by comparison with experiments using a packed-distillation column and water containing HTO.

A "Channeling Stage Model" was newly proposed to estimate the separative performances of a packed distillation column. Two channeling coefficients were defined: One represents a axial-mixing on concentration due to complicated passes in the packing bed, and another an efficiency on mass transport in a region corresponding to a packing size. A material balance equation in terms of the coefficients was derived, and solved analytically to give an explicit relation between the channeling coefficients and values of HETP that indicates separative performances. It enabled us to calculate the value of HETP.

A simulation model was proposed for analysis of mechanism of material transport in the packed column, and a new method was developed for diffusion process in vapor and liquid phases and for process of mass transport at the interface between vapor and liquid phases. The method enables us to estimate influence of velocity profile of vapor, reaction rate on vapor-liquid exchange and axial concentration profile in the liquid phase. Calculations and experiments were performed on separation of H_2O-HTO by two water-distillation columns with wetted-wall whose inner diameters were 6.0 and 16.0 mm, respectively. Comparison of calculated values with experimental data revealed that calculated values predicted characteristics of the experiments concerning dependence of the total separation factor upon the vapor rate, and upon the column radius walls. Validity of the present model was ensured as an analytical tool for prediction of the local separation of the packed column.

In water-distillation columns packed with 3.0 and 6.0 mmϕ respectively, impulse responses on liquid phase were measured. By comparison of the experimental response curve with calculated one, the channeling coefficient on a liquid phase was determined. The fact that the Peclet number in the present study was within the range of the reported values revealed validity of the present methods of simulation and experiment series.

Two series of experiments of H_2O-HTO separation were performed by a packed distillation column whose effective heights were 100 cm and packed with 3 and 6 mmϕ Dixon gauze rings, respectively. Values of HETP obtained from the channeling stage model were compared with those from the experiments, as shown in Fig. 1. Calculated values predicted experimental data on dependence of HETP upon vapor rate. Magnitude of efficiency of the material transport in the column packed with 6 mmϕ Dixon rings were larger than that with 3 mmϕ rings, while loss of separation due to the mixing in the column packed with 6mmϕ Dixon rings was smaller than that with 3 mmϕ rings. Due to compensation of the mass transfer with axial-mixing, values of HETP in the column with 6 mmϕ rings were not so different from those with 3 mmϕ rings, *i.e.,* the loss of separation was considerably large. Consequently, it was revealed that use of packed bed in which the mixing loss is small is considerably important for obtaining large separation factor.

The analytical method developed in the present study enables us to predict the HETP values and to optimize a number of factors affecting separative performances of the water-distillation, *i.e.,* a procedure were obtained for shortening of height of water-distillation column by cutting of overestimated margin on column design.

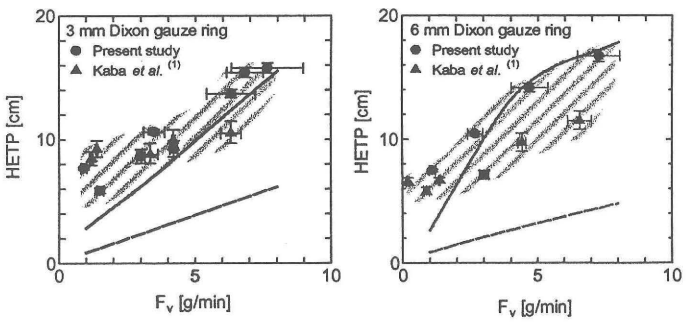

Fig.1 Comparison of the HETP values between experimental and calculated data