NUMERICAL STUDY ON COMPACTNESS OF VERTICAL PLATE ABSORBER

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A model of simultaneous heat and mass transfer process in absorption of refrigerant vapor into a lithium bromide solution of water-cooled vertical plate absorber was developed to evaluate the compactness of plate absorber and supply basis data for design of plate absorber. It is confirmed that there is an optimal plate interval minimizing plate absorber volume. And the smaller capacity for one piece of plate absorber, the smaller plate absorber volume is obtained.

INTRODUCTION

Absorption cooling systems have been widely used for the cooling of large buildings. Among major components of an absorption chiller/heater, the absorber has a direct effect on efficiency and size of the system. To achieve a compact and efficient absorber, plate absorber is used to replace shell and tube absorber.

Most of previous theoretical works on plate absorber such as the study of Grossman[1], Kawae et al.[2] dealt with the modeling of simultaneous heat and mass transfer in a film falling down a vertical plate. In these models, the liquid film was assumed falling down one side of plate and the refrigerant vapor pressure is constant along the plate width direction. However, in a real plate absorber, the refrigerant vapor pressure is decreased along the plate width direction.

The purpose of the present study is to develop a model of simultaneous heat and mass transfer process in absorption of refrigerant vapor into a lithium bromide solution of water-cooled vertical plate absorber to evaluate the compactness of plate absorber and supply basis data for design of plate absorber. Unlike most previous models, the change of refrigerant vapor pressure along the plate width direction was considered in this study. The analysis was carried out with three kinds of different capacity for one piece of plate absorber to investigate the effects of plate interval as well as the effect of capacity for one piece of plate absorber on plate absorber volume.

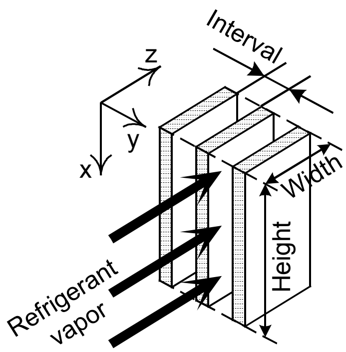
ANALYSIS MODEL OF PLATE ABSORBER

Model of entire plate absorber

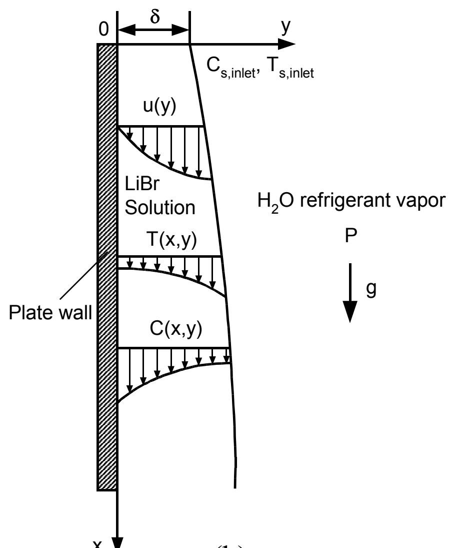
The schematic diagram of entire plate absorber is shown in figure 1(a). Vertical plates are set in a row with the same interval. Strong solution is equally distributed and flowed down each plate in both of plate side. The refrigerant vapor comes into absorber symmetrically at both of inlet side.

Model of solution falling film for each plate

The numerical analysis of the absorption process is described schematically in figure 1(b). A film of LiBr solution composed of LiBr (absorbent) and H_2O (refrigerant) flows down over a vertical plate. The film is in contact with refrigerant vapor and cooled by plate wall. The governing equations



(a)



(b)

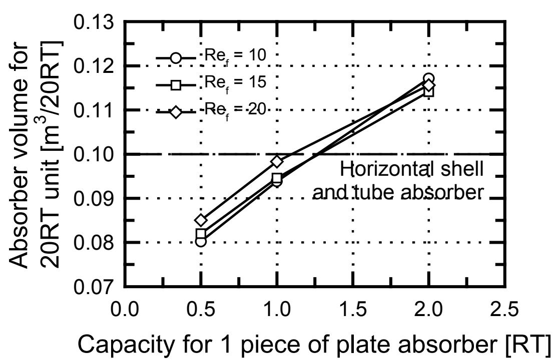
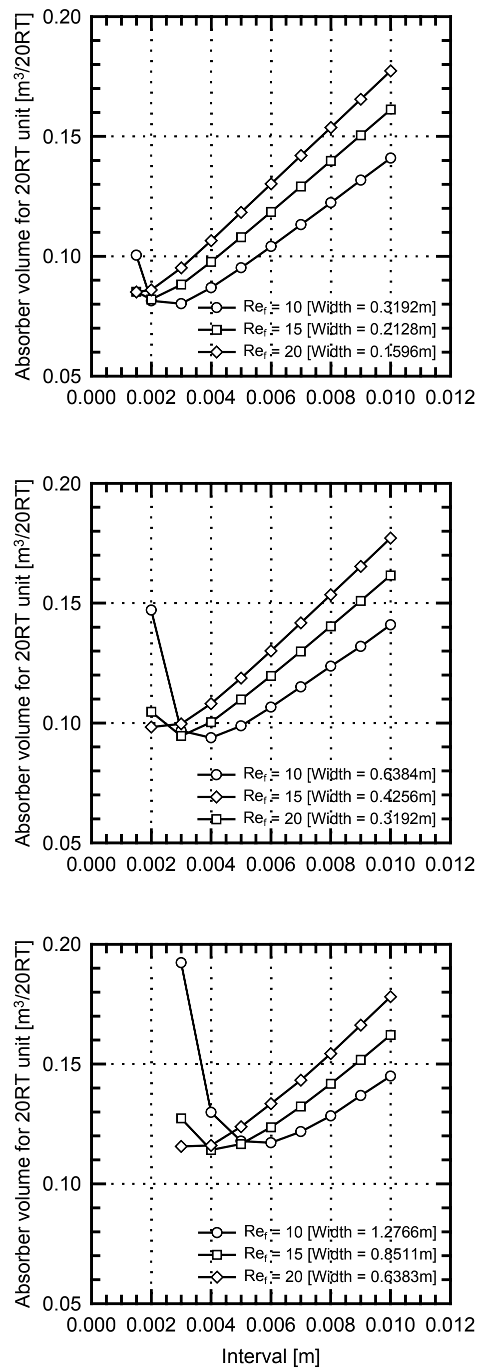


Fig. 3 Effect of capacity for one piece of plate absorber on plate absorber volume



(c) 2[RT/piece]

Fig. 2 Effect of plate interval on plate absorber volume

include energy equation and mass diffusion equation. The boundary conditions are applied at inlet and outlet solution, plate wall and liquid-vapor interface.

METHOD OF NUMERICAL ANALYSIS

Three kinds of capacity for one piece of plate absorber, which are 0.5RT, 1RT and 2RT, have been investigated to evaluate the compactness of plate absorber. In calculation, the integral forms of conservation equations were solved by the finite volume method proposed by Patankar[3]. The power-law scheme was used to treat the convection-diffusion term and get the discretization equations. The TDMA method was applied line by line to solve the system of discretization equations.

RESULTS AND DISCUSSIONS

Effect of plate interval on plate absorber volume

The effect of plate interval on plate absorber volume for 20RT plate absorber unit in the case of 0.5RT, 1RT and 2RT are shown in figures 2(a), (b), (c) respectively. The plate absorber volume decreases at the small value of the plate interval but increases at the high value of plate interval as plate interval increases. Therefore, it exists an optimal plate interval, which minimizes the plate absorber volume. In the case of 0.5RT and Reynolds number equals 10, the optimal plate interval is 3mm. In the case of 1RT and Reynolds number equals 10, the optimal plate interval is 4mm. Finally, in the case of 2RT and Reynolds number equals 15, the optimal plate interval is 4mm.

Effect of capacity for one piece of plate absorber on plate absorber volume

Figure 3 shows the effect of capacity for one piece of plate absorber on plate absorber volume. The plate absorber volume decreases as the capacity for one piece of plate absorber decreases.

The volume of horizontal shell and tube absorber is about $0.005m^3$/RT. In the case of 0.5RT, the plate absorber volume is 20% smaller than the volume of horizontal shell and tube absorber. In the case of 1RT, it is 6.2%. In the case of 2RT, the plate absorber volume is higher than the volume of horizontal shell and tube absorber.

CONCLUSIONS

It exists an optimal plate interval minimizing plate absorber volume. It is equal to 3mm in the case of 0.5RT.

The smaller capacity for one piece of plate absorber, the smaller plate absorber volume is obtained. The plate absorber volume is 20% smaller than the volume of horizontal shell and tube absorber in the case of 0.5RT.

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