

CHAPTER 1

INTRODUCTION

CHAPTER - 1

INTRODUCTION

Packed columns are being used in the chemical industry for gas/vapour - liquid contacting for nearly a century. The long survival of this equipment may be attributed to its features like inherent simplicity, operational flexibility and wide range of applicability. It is due to these features that packed columns predominate in number of installations as a gas - liquid contacting device.

Randomly packed columns are used for diverse applications such as gas absorption, pollution control, vacuum distillation, pressure distillation, olefin production, liquid extraction etc. Strigle (1) has discussed in detail, the applicational and industrial design aspects of packed columns for different operations. The applications of packed columns for gas-liquid and liquid-liquid reactions have also been discussed extensively by Doraiswamy and Sharma (2).

The design principles of packed columns stems out of the earliest theoretical work in chemical engineering in 1920's and 1930's; however it appears that although a proven technology, the industrial design of packed column does involve a substantial amount of empiricism. This is so because even now, there is lack of systematic information in the literature on some of the design

parameters such as effective interfacial areas available for mass transfer, true values of mass transfer coefficients etc.

In order to design a packed column for gas absorption one requires basic information regarding equilibrium conditions viz. Henry's law constant, gas and liquid flow rates and physical properties such as density, viscosity etc. Apart from these knowledge of column hydraulics viz, flooding velocity, gas pressure drop is required from which the column diameter could be evaluated. To perform pressure drop calculations under operating conditions, knowledge of liquid holdup becomes essential. Further knowledge of liquid and gas side volumetric coefficient ($k_L a$ and $k_G a$ respectively) are required to compute the values of the height of overall gas side transfer unit (H_{OG}), which in turn is utilised to calculate the column height to achieve the desired separation.

When mass transfer is accompanied by chemical reaction, the values of the interfacial area available for mass transfer (a), the true mass transfer coefficients (k_L) and (k_G) as well as the true liquid side coefficient with chemical reaction (k_L') are required independently. Danckwerts and Sharma (3) have considered the design of packed columns for gas absorption accompanied by chemical reaction.

The design parameters such as flooding velocity, liquid holdup, pressure drop, effective interfacial area and mass transfer coefficient have been studied by numerous investigators. Attempts to correlate experimental data on these parameters using semi

empirical correlations have also been made by some investigators. Predicting the values of flooding velocity, holdup and pressure drop by these generalised correlations appear to be appropriate and sound. However there exists considerable amount of discrepancy regarding the values of effective interfacial area and values of wetted surface area. In particular the values of interfacial area during absorption without chemical reaction (a_p) and interfacial area for absorption with chemical reaction (a_c) are not at all comparable under otherwise similar conditions.

Moreover, in order to estimate the true values of mass transfer coefficients k_L and k_G , from the corresponding values of the volumetric mass transfer coefficients $k_L a$ and $k_G a$ respectively, most investigators have used the values of wetted surface area. Thus, the predicted values of k_L and k_G are also expected to involve considerable amount of error.

Hence, designing a packed tower based on these semi empirical correlations is likely to lead to considerable error in estimating the height of the column.

Therefore, the experimental data available in the literature on the effective interfacial areas for gas absorption a_p and a_c , and wetted surface area could be analysed critically and correlations could be developed for predicting the values of effective interfacial area by mathematical modelling. Similarly, the available experimental data on volumetric mass transfer coefficients for the cases of absorption without chemical reaction as well as gas

absorption accompanied by chemical reaction could be analysed in a systematic manner. The values of the true gas side and liquid side mass transfer coefficients could then be predicted by utilising the appropriate values of effective interfacial area. The values of k_L and k_G obtained could then be utilised for developing generalised correlations by mathematical modelling. A suitable mathematical model could also be proposed for predicting the values of mass transfer coefficient with chemical reaction ($k_L'a$). Further, the generalised correlations so developed for different cases could also be used conveniently to elucidate the mechanism of mass transfer between gas and liquid in irrigated packed columns.

Hence this work was undertaken :

1. To formulate a mathematical model based on the concept of static area and dynamic area which is expected to represent the mechanism of mass transfer for the cases under consideration i.e. vaporization, absorption with or without chemical reaction and wetted surface area.
2. To obtain generalised correlations for predicting the values of effective interfacial area in terms of dimensionless numbers for the above mentioned cases by mathematical modelling.
3. To obtain generalised correlations for predicting the values of static area (a_{st}) and dynamic area (a_{dy}) and to utilise these correlations to throw light on the mechanism of mass transfer.
4. To obtain generalised correlations for predicting the values of true liquid side and gas side mass transfer coefficients using appropriate values of effective interfacial area.

5. To extend the concept of static area and dynamic area to mass transfer coefficients and to formulate a suitable mathematical model for predicting the values of $k_L'a$. Hence, also to obtain generalised correlations for predicting the values of mass transfer coefficients ($k_L'a$, $k_G'a$, $k_L'a$) for the case of absorption with chemical reaction.

6. To utilize the correlations of k_L , k_G and 'a' developed for the case of gas absorption, for predicting the packed height during distillation i.e. applicability of generalised correlations developed for gas absorption to distillation.