Expt. MT 304

Gas-Liquid Absorption

Objectives

1. Study hydrodynamic characteristics of packed columns.
2. Determine flooding characteristics of columns with three different packing.
3. Estimate mass transfer coefficient for absorption of ammonia into water.

Theory

Packed columns are used in chemical industry to absorb a gas from a mixture of gases or strip a volatile substance from a liquid. The columns are, usually, countercurrent gas-liquid contactors in which gas flows upward and liquid downward. To provide large interfacial area for mass transfer between gas and liquid, the columns are filled with packing.

Design of the column involves estimation of diameter of the column and height of the packing required for specified separation. The diameter is determined from flooding characteristics of the column and, the height is found from mass transfer characteristics of the packing and the gas-liquid system.

Flooding depends on pressure drop across the column, it being higher at the bottom and lower at the top to allow the gas to flow upward. The gas flow is usually turbulent and in a dry column, the pressure drop rises with gas flow with an exponent of 1.8 to 2.0 - a typical feature of turbulent flow. The pressure drop rises with an increasing flow of liquid because liquid fills up the column and the space for gas flow is reduced. Up to the loading point, the pressure drop follows the same relation as in dry run. Beyond the loading point, the pressure drop rises rapidly with gas flow and the liquid hold up in the column also rises. Eventually, at the flooding point, the pressure drop rises drastically and the liquid may splash back from the column. The gas velocity corresponding to the flooding point is called flooding velocity and the column is operated at some fraction of this velocity, say 60%.

Tower height is determined by packing characteristics, namely, interfacial area, mass transfer coefficient of the gas-liquid system and extent of separation. Refer to Cussler (1984) for derivation of governing equation for tower height.

Experimental Set-up

Figure MT 304.0.1 shows the experimental apparatus. It consists of three glass columns, each of 5 cm internal diameter and one meter packed height. Each column is packed with a different packing (Raschig
Rings, Pall rings and Intalox saddles). Examine the gas and liquid connections made to the columns. Gas and liquid should flow through only one column at a time. The pressure drop across the column is recorded with a differential pressure transmitter, which is connected to the computer (note that there is no read out for the transmitter). Air and ammonia flows are adjusted with rotameters; the two streams are mixed to produce a mixture of specified concentration (work with dilute concentrations, less than 5% ammonia). Liquid flow is manipulated with a peristaltic pump, which can be controlled by a computer. The temperature of the column is obtained with an RTD connected to the computer. The dissolved ammonia gas concentration is measured by Ion Selective Electrode instrument for ammonia.

Figure MT 304.0.1: Experimental Apparatus for studying hydrodynamics of a packed column and ammonia absorption
Procedure

Flooding

First, study dry-run pressure drop by flowing only air through one of the columns. Set air flow at 10 LPM and work your way up by raising it in increments of 10 LPM. Record the pressure drop for all air flows. Then, allow liquid to flow into the column and measure the pressure drop for increasing flow rates of gas. Use five different liquid flows starting from about 1.5 - 5 LPM. For each liquid flow, raise the gas flow slowly in increments of 10 LPM and record pressure drops. Repeat the above procedure for the other two packings.

Mass transfer

The packed height of the columns is one meter. From the equation given below, find HTU and then mass transfer coefficient for air/ammonia mixture and water system. Use mass balance to estimate gas phase concentration of ammonia in the outlet.

Report

It should include objectives, description of experimental apparatus, raw data and analysis of flooding and mass transfer.