

**STUDIES ON HYDRAULICS, HEAT AND MASS
TRANSFER IN A PACKED COLUMN**

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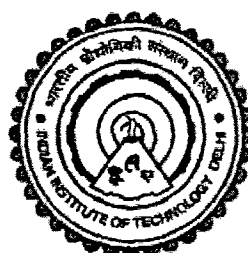
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Submitted

in fulfillment of the requirements of the degree of Doctor of Philosophy

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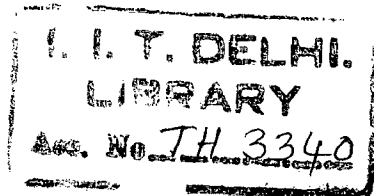


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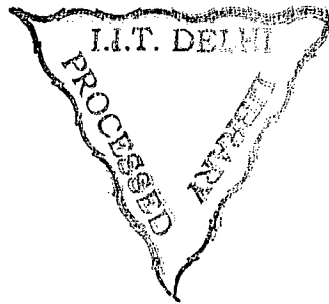
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Liquid distribution - packed column
Heat and mass transfer - Packed columns
Intalox metal tower packing - Heat Transfer



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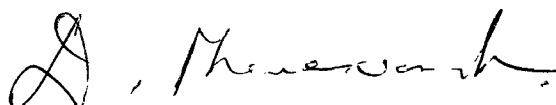


CERTIFICATE

This is to certify that the thesis entitled “**STUDIES ON HYDRAULICS, HEAT AND MASS TRANSFER IN A PACKED COLUMN**”, being submitted by **KAUSHIK MAJUMDER** to Indian Institute of Technology, Delhi for the award of Degree of Doctor of Philosophy is a record of the bonafide research work carried out by him. Mr. Kaushik Majumder worked under my guidance and supervision for his doctoral work and to my knowledge, the thesis submitted by him has reached the requisite standard.

The thesis or any part thereof has not been submitted to any other university or institute for the award of any degree or diploma.

July 19, 2006



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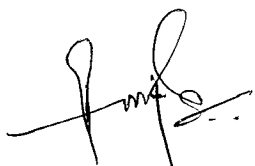
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(KAUSHIK MAJUMDER)

ABSTRACT

Packed columns are widely used for gas-liquid contact operations in chemical industries as well as in environmental applications to accomplish separation of components in the feed mixture. Knowledge of gas liquid parameters is important, specially in view of the advent of a large variety of new generation random and structured packings. IMTP (Intalox Metal Tower Packing) used in the present work is a high performance random packing. Published information on performance of IMTP is limited. Though a large number of correlations for gas liquid parameters are available in the published literature, it was felt necessary to examine their relevance to IMTP.

Present work has been designed with the following objectives:

- To design a column for proper gas and liquid distribution
- To conduct experiments on the following for estimation of gas liquid parameters:
 - Pressure drop, capacity and liquid holdup from air-water hydraulic studies.
 - Gas-side mass and heat transfer coefficients from simultaneous heat and mass transfer between hot dry air and cold water and direct contact condensation of steam from steam-air mixture into hot water.

Experiments were conducted by using four experimental setups consisting of 140mm/160mm diameter column, designed and built for studying maldistribution, hydraulic, humidification/dehumidification studies.

In the 140mm diameter Perspex column packed with IMTP-15 packing, significant wall flow was observed. The wall flow increased with axial distance from the

inlet of packed bed to a height at which the flow pattern stabilized. To correct the wall flow, and to maintain nearly uniform liquid distribution, it was found that one wall wiper type redistributor ring was required at every height equivalent to one column diameter along the packed bed.

Hydraulic studies were conducted in the 140mm diameter Perspex column with variable packing height and based on experimental data, models were developed for pressure drop, liquid holdup and capacity. Hydraulic performance of the packing was found to be affected by height of the packed bed due to strong interaction between gas and liquid at the gas entry point i.e. at the place where the gas risers were located on the support plate. The entrance effect was found to be significant in the case of shallow beds but with increasing bed height, the entrance effect was observed to be lesser as the gas flow became more uniform across the cross-section of the bed.

Low temperature dehumidification experiments were carried out in the above column. For high temperature dehumidification studies, a 160mm diameter stainless steel column was used. Gas side heat and mass transfer coefficients for the IMTP-15 packing were estimated by using a rigorous simulation model developed for this purpose. Strong influence of the packing height was observed on the values of the coefficients at low heights of packed bed.

The findings of the present work are of relevance in industrial applications where shallow packed beds are used for heat transfer services e.g. pump-around zones in refinery columns. In these services heat transfer coefficients are often underestimated without taking advantage of the entrance effect. Present work is likely to provide a better design methodology for such applications.

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