DIRECT CONTACT GAS-LIQUID HEAT EXCHANGE

BY

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THESIS
IN FULFILMENT OF REQUIREMENTS OF THE DEGREE
OF
DOCTOR OF PHILOSOPHY

TO

THE DEPARTMENT OF CHEMICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY
NEW DELHI

FEBRUARY, 1983

CERTIFICATE

This is to certify that the thesis entitled "DIRECT CONTACT GAS-LIQUID HEAT EXCHANGE" being submitted by Shri Anwar Haider Zaidi, to the Indian Institute of Technology, Delhi for the award of the degree of DOCTOR OF PHILOSOPHY is a record of a bonafide research work carried out by him. Mr. Zaidi worked under our guidance for the submission of this thesis, which to our knowledge has reached the requisite standard.

The thesis has not been submitted to any other University or Institution for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

With pleasure, I express my gratitude to Dr. S.C. Sarma for his stimulating guidance and help which has been available to me inspite of his busy schedule.

My sincere thanks are also due to Dr. P.D. Grover for his guidance and thoughtful suggestions which helped me in upgrading this study and bringing it to the present level.

I am grateful to Mr. Harish Abichandhani for his help and assistance which I received at various stages of this work. A word of thanks is due to Mr. Ashok Dodeja, Mr. Ashok Patel and Mr. R.S. Patel, for their help in the revision of manuscript.

Last, but not the least, the encouragement and support received from Dr.I.S. Verma, Director, National Dairy Research Institute, is gratefully acknowledged.

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ABSTRACT

The phenomenon of direct contact heat transfer (DCHT) from non-condensible gases to liquid has been investigated in detail. Due to the difference in heat transfer mechanism, the sensible heating and evaporation have been studied separately. In all, 9 systems, using 3 high boiling liquids i.e. glycerol, ethanediol and liquid paraffin were used for studies on sensible heat transfer. For experiments on evaporation, 7 systems employing 3 low boiling liquids i.e. carbon tetrachloride, acetone and water were selected. The gases used for heating were air, oxygen and carbon-dioxide. Experiments were performed within bubble flow regime only. For the estimation of interfacial area, suitable correlations have been obtained from literature and used.

Area heat transfer coefficients (U) calculated for various gas liquid combinations were found to depend upon the heat content of the gas and decreased with time or with the rise in liquid pool temperature. Increase in thermal conductivity resulted in increase in U value. However, the increased in viscosity of liquid phase adversely affected the process of heat transfer and caused the U value to drop.

Sensible heating of liquids under steady state by gas bubbles having counter current flow was found to be governed by the correlation

$$Nu = 8.58 \times 10^{-6} (Pe)^{1.505} (We)^{-0.735}$$

Weber number was incorporated in the correlation as the effect of liquid surface tension was found significant. Experimental data spread over 71 trials were predicted with 88.58% accuracy by the above correlation. U increased with both continuous and dispersed phase flow rate but remained unaffected by the change in bubble size for the range studied. The effectiveness for heat transfer calculated in terms of (UA/V) value was found from 2 to 9 times higher for DCHT as compared to tubular exchanger.

Smith's (99) correlation was found suitable for the estimation of heat transfer coefficient for evaporation and was used. The heat transfer coefficients were found in the range of 10 - 109 Kcal/m^2-hr-^{o}C. A model using heat and mass transfer analogy was developed for the estimation of mass transfer coefficient (EQ. 5.40). The mass transfer coefficient were found in the range of 0.5×10^{-5} - 25.5×10^{-5} kgmole/m^2-hr-Pa.

The process has potential for industrial application as it could be successfully employed for the concentration of milk. Appreciable rates of evaporation were obtained at subboiling temperatures and at atmospheric pressures. Heat economy was found in the range of 1.55 to 1.85 which approximated to that of a double effect evaporator. Inspite of low processing temperatures, the bacterial growth in milk was found contained and within permissible limits.

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