A THERMODYNAMIC STUDY OF DIETHYL-FORMAMIDE AND REFRIGERANT 22 COMBINATION FOR VAPOUR ABSORPTION REFRIGERATION SYSTEM

by

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DEDICATED TO

MY BELOVED MOTHER

CERTIFICATE

This is to certify that the thesis entitled 'A Thermodynamic Study of Diethyl-Formamide and Refrigerant 22 Combination for Vapour Absorption Refrigeration System' being submitted by Mr. M.S. Das to the Indian Institute of Technology, New Delhi for the award of the degree of Doctor of Philosophy in Mechanical Engineering is a record of the candidates own bonafide research work.

Mr. Das has worked under our guidance and supervison and has fulfilled the requirements for the submission of this thesis which, to our knowledge, has reached the requisite standard.

The results contained in this work have not been submitted, in part or in full, to any other University or Institute for the award of any degree.

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ABSTRACT

Vapour Absorption refrigeration systems have again assumed importance because of the recent energy crisis as these systems can make use of low grade heat energy sources, solar energy, geothermal energy, waste process heat etc. as against high grade energy required by the conventional vapour compression systems. The efficiency of these systems depends on the working combination used.

The present study attempts at detailed investigation of one such promising combination, viz., monochloro-difluoro-methane (R22)-Diethyl Formamide (DEF). This combination is free from inherent disadvantages associated with the conventional Ammonia-Water and Water-Lithiumbromide systems. Also, it fulfils most of the essential requirements for an efficient refrigerant-absorbent combination such as large solubility of refrigerant in the absorbent, large difference in their boiling points, non-toxicity, non-corrosiveness and high chemical stability over the complete working range of temperature and pressure. The R22-DEF combination gives large negative deviation from Raoult's law.

The method used for computation of thermodynamic properties from the experimental P-T-x data of the mixture makes use of separate thermodynamic equations for vapour and liquid phases. While Redlich-Kwong equation of state is used for the vapour phase, the liquid phase activity coefficients are

correlated with two-parameter Wilson equation. The method of non-linear regression has been used to obtain the required parameters. Another significant feature of this method is the assumption of reference state at $0^{\circ}C$ in the liquid phase for the individual components. Further, the properties of the vapour phase are related at this reference temperature. Also, a reference state of the vapour phase is established at $0^{\circ}C$ and zero pressure. The vapour-liquid equilibrium is then determined and the properties of the two phases are calculated separately from their respective reference states. Thus, the present method precludes the need of measuring or estimating latent heat of vaporisation.

The vapour pressure (P-T-x) data for the mixture have been measured with a high degree of accuracy over a wide range of temperature ($-30^{\circ}C$ to $160^{\circ}C$) and complete range of composition. The accuracy obtained in the measurement of pressures (with the help of a single U-Tube manometer or a series-compound mercury-water manometer) is about $\pm$ 1.0 mm of mercury. The temperatures were measured with the help of thermocouples with an accuracy of $\pm$ $0.025^{\circ}C$.

Burnett's method has been used for the measurement of P-v-T data for pure vapours of R22 and DEF. The measured data have been used to ascertain the applicability of the Redlich-Kwong equation for the present mixture and its components.

The properties of R22-DEF mixtures are computed over a wide range of temperature, pressure and composition using a computer program developed for the purpose. The results obtained are presented in tabular as well as in suitable graphical form. The important property diagrams, viz., the Ln P - $\frac{1}{T}$, Pressure-composition (Solubility characteristics), Temperature-composition and the enthalpy-composition etc. have been plotted.

A computer aided analysis and design method has been developed to study the suitability of the R22-DEF combination incorporating the basic thermodynamic relations starting from experimental P-T-x data. A detailed parametric study of the vapour absorption system has been carried out to show the effect of various operating conditions such as generator, condenser, evaporator temperatures and degree of subcooling on the system performance.

A comparative study of three combinations, viz. R22-DEF, R22-DMF and the conventional Ammonia-water, has also been made. The results indicate the superiority of R22-DEF system over the conventional Ammonia-water systems at all operating conditions. Also, this combination proves superior to R22-DMF at lower generator and higher condenser temperatures.

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