"THEORETICAL STUDY OF THERMODYNAMIC PROPERTIES OF FREON (FLUOROCARBON) REFRIGERANTS AND THEIR SPECIAL APPLICATIONS".

A B S T R A C T

The object of the present study is two fold. The first object is to study whether the thermodynamic properties of fluorocarbon refrigerants can be accurately determined by theoretical methods and the second object is to examine the possibilities of using these refrigerants as working media in power plants.

In order to achieve both these objectives, the thesis has been divided into two parts.

The first part of the thesis (Part A) consists of six chapters.

The first chapter is the introductory chapter in which the properties of Freon(Fluorocarbon) refrigerants and the necessity of theoretical evaluation of thermodynamic properties have been generally discussed.

In the second chapter the experimental methods adopted by previous investigators from time to time, for the determination of equations of state have been discussed. A critical analysis has been made of different equations of state suggested by different investigators and it has been shown that the usual method of determining the thermodynamic properties of Freon refrigerants from equations of state, is very cumbersome and is not likely to give accurate results above the critical point. Two alternative experimental methods based on the principles of enthalpy measurement have been suggested in this chapter.

The third chapter deals with theoretical estimation of critical properties by three different methods. A consolidated table of critical properties of 17 Freon refrigerants based on

theoretically estimated values has been given in this chapter. These values will be very useful for refrigeration engineers and Freon turbine designers. Many of these critical properties were reported by the author for the first time in 1970.

The fourth chapter deals with theoretical estimation of ideal gas heat capacities. A table showing ideal gas heat capacities (C_p^*) of 15 Freon refrigerants has been given in this chapter. These values will be useful for other workers in this field to estimate enthalpy and entropy values of other refrigerants based on the method described in the fifth chapter. It has been shown that the method described in this chapter also holds good for azeotropic mixtures of Freon refrigerants. Most of the ideal gas heat capacity equations were reported by the author for the first time in 1969.

The fifth chapter contains detailed procedure of theoretical evaluation of saturation pressure, latent heat of vaporisation, heat capacity, enthaply and entropy of Freon refrigerants. The theoretically calculated values of enthalpy and entropy of Freon 12 and Freon 11 have been compared with the published experimental values and it has been shown that the theoretically estimated values obtained with the help of methods described in the thesis, are reasonably accurate for engineering calculations. A pressure-enthalpy diagram ~~knuth~~ together with a Mollier Chart for Freon 11, drawn well into the Super-critical region has been given in this chapter. This diagram will be very useful for Freon turbine designers.

The procedure given in this chapter was reported by the author for the first time in 1966. This method will enable other workers in this field to evaluate theoretically the thermodynamic properties of other Freon refrigerants. In this chapter a comparison has also been made with Badylkes' theory of thermodynamic similarity.

The sixth chapter contains the conclusion relating to the first part of the thesis.

The second part of the thesis (Part B) consists of five chapters. The first chapter gives an introduction regarding Freon turbines. It has been shown in this chapter that Freon turbines have many advantages over steam turbines within specified temperature limits. Freon turbines can be usefully employed to generate power out of the exhaust gases of Gas Turbines, Internal Combustion Engines or steam power plants. Detailed calculations regarding Freon turbines were made by the author for the first time in 1963 and were published in 1965.

The second chapter deals with detailed design calculations relating to the working of a Freon turbine, out of the waste heat of a Gas Turbine. It has been shown in this chapter that it is possible to obtain about 20% additional power by utilising the waste heat of a gas turbine in a Freon turbine. These calculations were published in a condensed form in 1967.

The third chapter deals with Power Plant cycles using only refrigerants. In this chapter it has been shown that Refrigerant 11, 12, 22 and 113 can be used advantageously as working media in super-critical power plants within the

temperature limit of 590°F. At the same time it has also been proved that sub-critical cycles using common Refrigerants as working fluids yield low efficiencies and hence these should not be tried. It has been shown that Carbon Tetrafluoride, if used in a Brayton cycle yields a thermal efficiency of about 32 percent within the temperature range of 700°F and 100°F.

The fourth chapter contains the conclusion ~~of~~ relating to the second part of the thesis.

The fifth chapter deals with "Future Scope of Work".

At the end of the thesis a list of all references and a Bibliography have been added.

Five reprints have been enclosed with the thesis.

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