HEAT TRANSFER IN LATENT HEAT THERMAL STORAGE MATERIALS & SYSTEMS

by

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dedicated to

MY PARENTS

CERTIFICATE

It is certified that the thesis entitled 'Heat Transfer in Latent Heat Thermal Storage Materials and Systems', being submitted by Mr.Dhram Buddhi is worthy of consideration for the award of the Degree of Doctor of Philosophy and is a record of bonafide research work carried out by him under our guidance and supervision. The results contained in this thesis have not been submitted in part or full to any other University or Institute for the award of any degree or diploma.

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PREFACE

Use of solar energy is often limited by the problem of thermal storage. The most popular and reliable way of storage so far has been the sensible heat storage in water or other materials. The systems developed are usually heavy and also give rise to problems like corrosion, leakage, stratification etc. The use of phase change storage materials for storing heat in the form of latent heat has been recognised as one of the potential area to provide compact and efficient solar thermal storage systems. Constant temperature can be obtained by employing latent heat storage systems.

The state of the development of the PCM's remain however unsatisfactory. The reasons being the lack of knowledge about adequate materials and the difficult mathematical analysis posed by the moving boundary value problem.

The latent heat of fusion and melting temperature of the phase change materials is the main criteria for determing the performance of thermal storage systems. Usual methods employed are Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) which employ costly equipment. A new simple apparatus based on the technique of DTA has been developed. This apparatus is able to give the result within an accuracy of 3%.

The classifical Stefan Problem (moving boundary value) is solved for plane geometry by assuming that convection is the dominant mode of heat transfer at the interface and the tempera-

ture distribution in the solid PCM oscillates periodically with the frequency of 24 hr time period.To validate the developed theoretical model, experiments were performed. A good agreement is seen between the theoretical and experimental results within the domain of the applicability of theory. The calculations for the moving boundary problem are done for different materials and different climatic conditions of India.

The theoretical analysis for the Stefan problem is extended for cylindrical geometry to solve the problem of a separate collector and a separate thermal storage system. The system is seen later to have thermal efficiencies which are dependent on climatic conditions.

Using quasi-steady state conditions, a thermal analysis has been developed for a collector cum storage system using phase change materials. Performance equations of the type of Hottel-Whillier Bliss (HWB) equations for flat plate collectors, have been obtained for the system. Calculations have been performed for a wide range of parameters to investigate the applicability of the developed model.

The solutions help to understand the heat transfer in such materials in a much better way. The calculations have been performed to size the system parameters and storage size. The whole work presented in various chapters has resulted in the following publications.

(i) D.Buddhi, R.L. Sawhney, P.N. Sehgal and N.K. Bansal,

A simplification of the differential thermal analysis method to determine the latent heat of fusion of phase change materials, J.Phys. D; Appl. Phys.20, 1601-1605 (1987).

(ii) D.Buddhi, N.K. Bansal, R.L. Sawhney and M.S. Sodha, Solar thermal storage systems using phase change materials, Int. J. Energy Research (1988) (In Press).

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