THERMAL PERFORMANCE OF SOME SOLAR AIR - HEATING SYSTEMS

by

SARVESH KUMAR BHARADWAJ

Thesis submitted to the Indian Institute of Technology, Delhi
for the award of the Degree of
DOCTOR OF PHILOSOPHY

Centre of Energy Studies
INDIAN INSTITUTE OF TECHNOLOGY, DELHI
NEW DELHI (INDIA)
1986

Dedicated

To My Parents

CERTIFICATE

This is to certify that the thesis entitled "THERMAL PERFORMANCE OF SOME SOLAR AIR-HEATING SYSTEMS" being submitted by Mr. Sarvesh Kumar Bharadwaj to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy, is a record of the original bonafide research work carried out by him under our supervision and that 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/diploma.

(Dr. A. Kumar)

(Prof. M.S. Sodha)

ACKNOWLEDGEMENTS

I have no befitting words to express my deep sense of gratitude to Prof. M.S Sodha, Head, Physics Department, a blessing to the scientific community, who has always been a source of inspiration and invaluable guidance during this task.

I am highly grateful to Dr. Ashvini Kumar whose remarkable way of supervision, worthy discussions, unstinting efforts and intact affection made me possible to complete the work timely.

I feel highly obliged to Dr. N.K. Bansal and Dr. I.C. Goel for useful discussions.

I am highly indebted to Prof. P.D. Grover, Prof. S.S. Mathur and Prof. H.P. Garg for all sorts of help during this study.

My sincerest thanks are also due to Dr. A.K. Sharma, Dr. R. Raman Dr. R.L. Sawhney, Dr. J. Kishore, Dr. Govind, Dr. N.D. Kaushika and Dr. S.C. Kaushika for useful suggestions.

I can not help paying my respectful regard to Dr. M.L.Devgun, my real and true benefactor, for his divine helps.

I wish to thank my colleagues, S.B. Sharma, Anil Mishra, Arvind Goel, S.P. Singh and D. Budhi for their valuable time shared during the events of joy and sorrow equally.

Last but not the least, I feel owed to my brothers, Dr.S.S. Bharadwaj, Er. S.D. Bharadwaj and Er. S. Kumar as I achieved this target due to their good-wishes only.

For my wife, Alpana Bharadwaj, I will keep mum because neither she can be thanked, nor ignored.

I would also like to thank Mr. D.R. Joshi for his elegant typing of the thesis. Thanks are also due to Mr. Sushil Singh for his kind help in making the figures.

(Sarvesh Kumar Bharadwaj)

SUMMARY

The present thesis deals with the thermal modelling and techno-economic optimization of some solar air-heating systems. It opens with a brief discussion about the state-of-art of these systems. In chapter 1, a simple analytical model for overlapped-glass-plate solar air heater is developed which is validated with the experiments conducted elsewhere. The next two chapters present two innovative designs of solar air heating systems which consist of thermal-storage also in the form of ground and water respectively. The numerical calculations have shown that these systems store substantial amount of heat and can also be used during off-sunshine hours for low temperature applications. Since every climate has certain days when the hot air demand can not be met by solar system alone, this may be coupled with an auxiliary heating system. Chapters 4 and 5 propose two such systems which consist of simple solar air-heater and a solar collector-cum-storage system respectively; the storage of heat is provided in the form of water. In order to study these systems, suitable techno-economic models have been developed yielding the optimized values of various design parameters which correspond to the minimum cost of useful energy. The optimum value of the unit cost of useful energy from these systems has been seen to be much less as compared to the unit cost of electricity.

One of the important problems associated with the transportation of hot air is the use of insulation. Chapter 6 deals

with optimization of the insulation thickness corresponding to maximum net savings over various pipes carrying hot air at different temperatures, and evaluating the optimum distribution of insulation for a given investment.

CONTENTS