

STUDY OF TOP HEAT LOSS FACTOR OF FLAT PLATE SOLAR COLLECTOR

*A THESIS SUBMITTED TO THE
INDIAN INSTITUTE OF TECHNOLOGY, DELHI
FOR AWARD OF DEGREE OF
DOCTOR OF PHILOSOPHY*

By
SANJOY KUMAR SAMDARSHI



**Centre for Energy Studies
INDIAN INSTITUTE OF TECHNOLOGY, DELHI
NEW DELHI - 110016
March 1992**

TO--

MY PARENTS

CERTIFICATE

It is certified that the thesis entitled "Study of Top Heat Loss Factor of Flat Plate Solar Collector" being submitted by Mr. Sanjoy Kumar Samdarshi is worthy of consideration for the award of the degree of Doctor of Philosophy and is a record of original bona fide research work carried out by him under my 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/diploma.



(Dr. S. C. Mullick)
Professor
Centre for Energy Studies
I. I. T., Delhi
New Delhi - 110 016

ACKNOWLEDGEMENT

First of all I would like to pay tributes to Lord Ganesha, the symbol of wisdom and super-consciousness.

I feel privileged to express my deepest gratitude to my supervisor Prof. S. C. Mullick for his valuable guidance and continuous encouragement. At every stage of my doctoral work it was his support which kept my enthusiasm alive. I would also like to thank Mrs. Sumedha Mullick for her help during the writing and checking of my thesis.

I am indebted to Dr. T. C. Kandpal for his help and inspiration. I avail this opportunity to express my sincerest thanks to Prof. M. S. Sodha, Prof. S. C. Tripathy and Prof. H. P. Garg.

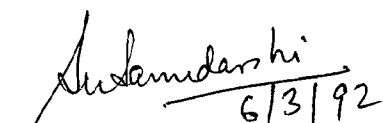
I owe thanks to Dr. Chandrashekhar Sinha for his unstinting help and support during all the stages of my research work. Thanks are also due to my friend Mr. V. B. Sharma for his continuous support and help specially in preparing my experimental set-up.

The co-operation and help rendered by Mr. U. K. Singh, Md. Rafiqui Islam, Mr. Rajendra Adhikari, Ms. Punita Taneja, Mr. Subodh Kumar, and all the members of Power Systems Laboratory is acknowledged with thanks.

I wish to thank my friends Mr. Arun Bijalwan, Mr. Rajiv Ranjan, Mr. Asit Kumar, Mr. P. K. Singh, Mr. Ram Vinay Sharma, Mr. Ghanshyam, Mr. Shyam Rudra Pathak, Mr. Sudhakar Thakur and specially to Mr. Ajit Kumar for his help during the final stages of my thesis writing.

I want to put on record my appreciations and thanks for all the friends, faculty and staff members of Centre for Energy Studies.

I must thank my parents and my younger brother Yatindra Mohan for their moral support and co-operation. Thanks to all my family members including my uncle Prof. A. P. Sharma, Mr. C. B. Sharma and Cousins A. Priyadarshi, A. K. Satyajit, Sandeepan, and Abhay. Thanks also to my cousin and local guardian Mr. Mithilesh Sharma for his inspiration and encouragement at the time when it was needed most. Words are not enough to express my gratitude to my wife, Pratima, for her support, understanding and patience without which this work would not have been possible.


6/3/92
(S. K. Samdarshi)

INDEX

Certificate
Acknowledgement
Nomenclature
Index

Chapter-1:Introduction	1.1-1.29
1.1 Flat plate collector	1.2
1.2 The absorptance - transmittance product	1.5
1.3 The overall heat loss factor	1.7
1.4 The top heat loss factor	1.9
(a) The radiative heat transfer coefficient	1.9
(b) The convective heat transfer coefficient	1.12
Previous work on top heat loss factor	1.17
Chapter-2:An improved technique for computing the top heat loss factor of a flat-plate collector with a single glazing	2.1-2.20
2.1 The heat balance and the Individual Heat -Transfer coefficients for a flat plate absorber with a single glazing	2.4
2.2 The Individual Heat-Transfer Coefficients.	2.6
2.3 The proposed method: Using the heat loss equation in the analytical form	2.8
2.4 Comparison of results obtained by the proposed analytical equation with numerical solution and the semi-empirical equations	2.14
2.5 Study of results obtained over different possible combinations of the independent parameters	2.16
2.6 Discussion	2.17
Chapter-3:Analytical equation for the top heat loss factor of a flat-plate collector with double glazing	3.1-3.14
3.1 Heat Balance and The Top Heat Loss Factor for a Flat Plate Collector with Double Glazing	3.3
3.2 The Proposed Analytical Equation for the Heat Loss Factor	3.5
3.3 Comparison of results obtained by the proposed equation with numerical solutions and the sem- empirical equation	3.9

3.4	Study of results obtained over different possible combinations of the independent parameters for a collector with two glass covers	3.10
3.5	Discussion	3.11
	Appendix 3.1	3.15
Chapter-4: Analysis of the top heat loss factor of flat plate solar collectors with single and double glazing 4.1-4.10		
4.1	Analytical Equations for U_t	4.3
4.2	Dependence of the glass cover temperatures, the individual heat transfer coefficients, and the top heat loss factor on the basic parameters	4.4
	(i) Flat Plate Collector with Single Glazing	4.4
	(ii) Flat Plate Collector with Double Glazing	4.7
4.3	Discussion	4.9
Chapter-5: Generalized analytical equation for the top heat loss factor of a flat plate solar collector with N glass covers 5.1-5.15		
5.1	The heat balance and the top heat loss factor for a flat plate collector with N glass covers	5.4
5.2	The Proposed Analytical Equation for the Top Heat Loss Factor	5.6
	The Top Heat Loss Factor when $T_g \neq T_a$	5.9
5.3	Comparison of results obtained by equation(5.7) or equation(5.10) with numerical solution and the semi-empirical equations	5.11
5.4	Discussions	5.13
Chapter-6: A method for representing experimental results for top heat loss factor in flat plate collectors 6.1-6.14		
6.1	Simulation study of expression forms to represent the factors(U_i , U_0 , and U_t) in upward heat flow for a given collector	6.4
6.2	Suitable expression forms to represent the upward heat flow factors (U_i , U_0 , U_t) and the proposed procedure	6.6

6.4 Discussion	6.11
Appendix 6.1	6.15
Chapter-7: Experimentation and analysis of results on heat losses in flat plate collectors	7.1-7.13
7.1 Test set-up and experimental procedure	7.2
Experimental procedure	7.5
7.2 Experimental results and analysis by the proposed method	7.5
Analysis by the proposed method	7.7
7.3 Discussion of results	7.10
Appendix-A: Analytical equation for the heat loss factor of a perfectly evacuated coaxial tubular collector	A.1-A.5
Appendix-B: Estimation of hemispherical total emittance of a tubular absorber from heat loss tests	B.1-B.7
Appendix-C: Application of the analytical equation in case of a different enclosed gas	C.1-C.3
References	
Abstracts of published research papers	