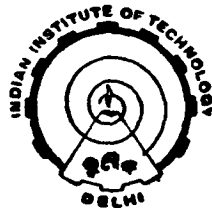


**EVALUATION OF THE PERFORMANCE OF VARIOUS  
SOLAR ENERGY COLLECTOR SYSTEMS.**

*Thesis submitted to the Indian Institute of Technology, Delhi  
in fulfilment of the requirements  
for the award of the degree of  
DOCTOR OF PHILOSOPHY*

**RATNA CHAUDHARY**



**CENTRE FOR ENERGY STUDIES,  
INDIAN INSTITUTE OF TECHNOLOGY, DELHI,  
NEW DELHI - 110016,  
JULY 1990**

SARRADDHA

SABURO

LIBRARY DELHI

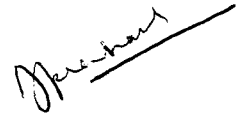
**TO MY PARENTS**

## CERTIFICATE

It is certified that the thesis entitled "Evaluation of the Performance of Various Solar Energy Collector Systems" being submitted by Mrs. Ratna Chaudhary is worthy of consideration for the award of the degree of Doctor of Philosophy and is a record of original bonafide research work carried out by her 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/diploma.



Prof. H.P. Garg  
Centre for Energy Studies  
I.I.T. Delhi  
New Delhi



Dr. J. Prakash  
Univ. of Delhi  
Delhi.

## ACKNOWLEDGEMENTS

It is my great pleasure and privilege to express my profound indebtedness to Prof. H.P. Garg for his inspiration, stimulating discussions and unstinting guidance at all stages of this work, as a consequence of which the present study reached fruition.

Grateful thanks are also due to Dr. Jai Prakash for supervising the thesis work and also for his interest and support.

The most valuable discussions with Dr. Ram Chandra and Dr. (Mrs.) N.K. Dhiman were responsible in the execution and interpretation of the problems for which I wish to express my heart felt thanks and gratitude.

Let me convey my sincere thanks to Prof. M.S. Sodha, Prof. P.D. Grover and Prof. S.C. Tripathi for the interest shown in my work and for their encouragement at all stages of this work.

The cooperation and help rendered by Dr. Hrishikesan, Dr. (Mrs.) C. Chaudhary, Dr. (Mrs.) Rashmi Rakshit, Dr. (Ms.) Rekha Bhowmik, Dr. (Ms.) Priti Kashyap, Mrs. Ranjana Jha, Mr. A. Trisal, Miss Anees, Mr. Y.P. Singh, Mr. K. Behari, Mr. Ram Niwas and all my friends at Kailash Hostel is hereby acknowledged with thanks.

I must thank my both set of parents and my family, for their love, moral support and cooperation which has made this piece of work successfull. Finally my sincere thanks to my husband Mr. L.K. Chaudhary for his support, active interest and encouragement without which this work would not have been possible or as he says would have been over much earlier (!).

*Ratna Chaudhary*

Ratna Chaudhary

## CONTENTS

	Folio
CHAPTER-I : INTRODUCTION	
PREFACE	1-18
CHAPTER-II: OPTIMIZATION OF SOLAR AIR HEATERS OF DIFFERENT DESIGNS	
2.1 INTRODUCTION	19
2.2 ANALYSIS	23
2.2.1 Annual Useful Heat	27
2.2.2 Annual Pumping Cost	27
2.2.3 Annual Collector Cost	28
2.3 THERMAL EFFICIENCY	29
2.4 NUMERICAL INPUT PARAMETERS	30
2.5 TABULATION OF THERMAL EFFICIENCY OF VARIOUS COLLECTOR DESIGNS	31
2.6 RESULT AND DISCUSSION	32
2.7 CONCLUSIONS	36
2.8 APPENDIX	38
NOMENCLATURE	40
REFERENCES	42
CHAPTER-III: PARAMETRIC STUDIES ON THE CORRUGATED SOLAR AIR HEATERS WITH AND WITHOUT COVER	
3.1 INTRODUCTION	45
3.2 ANALYSIS	48
3.2.1 For the Single Cover Collector	52
3.2.2 Annual Useful Heat	55

3.2.3	Annual Pumping Cost	56
3.2.4	Annual Collector Cost	57
3.3	NUMERICAL INPUT PARAMETERS	58
3.4	RESULTS AND DISCUSSION	59
3.5	APPENDIX 1	66
3.6	APPENDIX 2	68
	NOMENCLATURE	70
	REFERENCES	72
CHAPTER-IV:	OPTIMIZATION OF A TRIPLE PASS SOLAR AIR HEATER	
4.1	INTRODUCTION	75
4.2	ANALYSIS	79
4.2.1	Annual Useful Heat	85
4.2.2	Annual Pumping Cost	85
4.2.3	Annual Collector Cost	87
4.2.4	Thermal Efficiency	88
4.3	NUMERICAL INPUT PARAMETERS	89
4.4	HEAT TRANSFER COEFFICIENTS (TABLE 2)	90
4.5	RESULT AND DISCUSSION	90
	APPENDIX	94
	NOMENCLATURE	98
	REFERENCES	100
CHAPTER-V:	STUDY OF THERMAL PERFORMANCE OF A BLACK LIQUID SHALLOW SOLAR POND UNDER VARIOUS OPERATING CONDITIONS.	
5.1	INTRODUCTION	105
5.2	ANALYSIS	106

5.2.1	Fixed Outlet Temperature	110
5.3	TABLE NO.2	112
5.4	RESULT AND DISCUSSION	114
5.5	CONCLUSIONS	116
5.6	TABLE NO.1	117
	NOMENCLATURE	118
	REFERENCES	119
CHAPTER-VI:	TRANSIENT ANALYSIS OF N COLLECTOR ARRAY UNDER DIFFERENT CONFIGURATIONS	
6.1	INTRODUCTION	123
6.2	ANALYSIS AND CALCULATIONS	127
6.3	NUMERICAL INPUT PARAMETERS	132
6.4	MEAN EFFICIENCY OF DIFFERENT COLLECTOR COMBINATIONS	
6.5	RESULT AND DISCUSSION	133
6.6	CONCLUSIONS	134
	REFERENCES	136
	NOMENCLATURE	138
CHAPTER-VII:	STUDY OF THERMAL PERFORMANCE OF A MULTIPLE PASS SOLAR COLLECTOR	
7.1	INTRODUCTION	140
7.2	ANALYSIS	144
7.3	VALUES OF WEIGHING FACTORS AND ABSORPTION COEFFICIENTS OF WATER FOR SOLAR RADIATION	147
7.4	RESULT AND DISCUSSION	148
	NOMENCLATURE	150
	REFERENCES	151