

# **THEORY AND APPLICATIONS OF EVACUATED TUBULAR SOLAR ENERGY COLLECTORS**

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



**Centre For Energy Studies**  
**INDIAN INSTITUTE OF TECHNOLOGY, DELHI**  
January, 1986

DEDICATED TO

MY PARENTS

WITH WHOSE BLESSINGS

COULD RISE TO THIS LEVEL

CERTIFICATE

It is certified that the thesis entitled "Theory And Applications of Evacuated Tubular Solar Energy Collectors" being submitted by IndraJit is worthy of consideration for the award of the degree of Doctor of Philosophy and is a record of the original 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 award of any degree or diploma.

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## ACKNOWLEDGEMENTS

It is my great pleasure and privilege to express my deep sense of gratitude and profound indebtedness towards Dr. N.K. Bansal and Prof. H.P. Garg for their incessant, invaluable guidance, direction and inspiring encouragement and kind co-operation at each and every phase of this research work. I wish to express my deep sense of gratitude and indebtedness to Dr. R.L. Sawhney Physics Department, M.L.N. College Moti Bag New Delhi for his unstinting guidance and help without which the completion of this work would not have been possible.

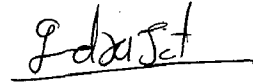
The encouragement and continuous interest of Prof. M.S. Sodha and Prof. S.S. Mathur is gratefully acknowledged.

My heartfelt thanks are also extended to Prof. P.D. Grover, Head, Centre of Energy Studies and other staff members for their encouragement advice and timely help at every stage of the research work.

My special thanks go to my colleagues and friends Mr. D.S. Hrishikesan, Mr. S.N. Garg, Satyendra Mishra and Ajay Kumar Agarwal for their valuable assistance and fruitful discussions, I had during the course of their work.

I also wish to appreciate the co-operation extended by the technical and administrative staff of the centre.

I have no befitting word to express my deep sentiments towards my parents and other members of my family, particularly my younger brother Mr. Shayam Singh and younger sister Mrs. Vddhya for their unending tolerance and moral support during the course of this work.

A handwritten signature in cursive script, appearing to read 'Indrajit', written over a horizontal line.

(INDRAJIT )

## ABSTRACT

Large application of solar energy have been essentially confined so far to low temperature applications such as water heating, air heating, solar desalination etc. for such applications flat plate collectors are adequate. The flat plate collector have been well categorised and understood.

For applications in the range of temperature between 100 and 150°C, the evacuated tubular collectors are in use. Several designs of such collectors such as Owens Illinois, General-Electric Evacuated tubular collector, Corning Evacuated Tube collector, Philips design, Sayno design etc. have been forwarded. But, in recent years, a theory behind the development of design has been lacking. The current thesis is an effort which aimed at providing such a theory for these collectors. The thesis start with an introduction giving detailed features of tubular collector. Basic mechanism of achieving higher temperatures at relatively high efficiency has been reviewed. The details of various designs, available in market, have been presented.

A steady state analysis of tubular collector and a clever formulation leads to explicit expressions for the rating parameters of the collectors which has been presented in Chapter II. The equations can be used as

design tools for such a collector. CPC booster is very often used along a tubular collector, its effects therefore has been incorporated in Chapter III. Any defect in fabrication of tubular collectors may lead the leakage of vacuum which adversely affects the performance. This also has been studied in Chapter III. In the analysis of collectors one usually assumed a uniform temperature distribution over the plate. In the case when a CPC collector is used, the temperature distribution does not remain uniform especially when the conductivity of absorber is low. The effect of non-uniformity of temperature distribution has been analysed in chapter IV. It was observed that a new parameter has to be defined to characterize the performance of tubular collector especially when the mass flow rate of liquid is small. If the fluid channel is in the form of U-tube then the temperature of the absorber in a direction perpendicular to the direction of fluid flow also does not remain constant. A rigorous theory to study this effect has been developed in Chapter V. The work presented in Chapter I-V, therefore establishes a theoretically sound bases for the performance of evacuated tube characteristics and lay down the foundation of evolving design patterns for the fabrication of such collectors.

Besides the usual applications of tubular collector operating in the intermediate temperature range such as process heat, air conditioning and refrigeration etc., one of the very important applications specially for rural dispensary i.e. solar steriliser has been forwarded analysed and studied in detail in chapter VI.

It is hoped that this thesis will present the basic background for further develop of evacuated tube collector and simultaneously the interested industry will take up the job of fabricating a solar steriliser.

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