# SOME DESIGN STUDIES ON SOLAR ENERGY CONCENTRATORS

by

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TO MY PARENTS

AND ABOVE ALL A NOBLE SOUL

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## SUMMARY

The present thesis deals in detail with the design studies on solar energy concentrators.

An analytical study of a stationary (non-tracking) and non-stationary (tracking) concentrator composed of plane mirrors has been carried out. The concentration factor is found to depend on mirror angles, acceptance angle and number of mirror pannels. It is concluded that large savings in reflecting surfaces are possible while sacrificing marginal reduction in concentration ratio. It is expected that on increasing the number of mirror pannels, the concentration will tend towards that of a compound parabolic concentrator.

An experiment was set up, working out in detail, the solar conical concentrator. A detailed analytical treatment of heat exchange at the different surfaces of the absorber, an evaluation of the appropriate heat transfer coefficients, and solution of the energy balance equation for cylindrical absorbers is included. Theoretically and experimentally it was seen that the wind velocity increases the heat loss coefficient, and hence time required to attain the boiling point on a windy day will be more. In addition to it, time required for steam generation with different sizes of the absorber were also determined.

Optical and thermal properties of trough like concentrators have also been investigated. A simple analytical technique for calculating the average number of reflections have been developed. This is helpful for computing optical losses. Effective emissivity $\varepsilon_{eff}$ and the collector efficiency $\eta$ increase with an increase in the concentration factor.

Collector, collector-reflector system in south and off-south orientation for different centres in India has also been investigated. The effect of change in relative sizes and tilt angles of both collector and reflector on the collector and collector-reflector performance is discussed. The shading of the collector by the reflector has also been considered in the analysis. It was concluded that there is an optimum value of collector tilt for a given azimuthal angle, at which yearly effectiveness is maximum. The percentage enhancement due to the presence of a reflector was also studied for different changes in relative parameters. It was seen that for a reflector size and width ratio $\simeq 1$, sufficient enhancement is obtained. Further increase causes only marginal increase in the enhancement of solar energy.

To investigate the thermal performance of a collector, reflector-collector systems, fourier coefficients of solar intensity and ambient temperature

were calculated. An analytical and experimental study for water temperature for both systems were determined at different water flow rates.

Solar flux distributions produced by circular cylindrical concentrators have been determined. An integral relationship for evaluating the energy density distributions on receivers of arbitrary shape has been developed. The solar intensity distributions have been calculated for flat and cylindrical receivers. It was also found that in the case of cylindrical receivers, the local concentration ratio decreases with an increase in radius of receiver as well as with rim angle of the receiver.

TABLE OF CONTENTS

CHAPTER VII