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Development and performance analysis of compound parabolic solar concentrators with reduced gap losses—'V' groove reflector

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Abstract

A system has been developed to use compound parabolic concentrators to collect solar energy and to generate steam. A CPC reflector profile with a V groove at the bottom of the reflector to reduce the gap losses was designed with a half acceptance angle of 23.5° for a tubular absorber of OD 30 mm. Five troughs fabricated with fiberglass substrate pasted over with UV stabilized self-adhesive aluminized polyester foil having high specular reflectivity joined together side by side comprise the CPC module with an aperture area of 2.04 m^2. Copper tubes coated with NALSUN selective coatings and enclosed by borosilicate glass envelope act as absorbers. The reflector absorber assembly housed in a single glass wool insulated wooden box forms the CPC collector. Using water as the heat transfer fluid efficiency tests were carried out with different inlet temperatures. In situ steam generation testing and possible application to steam cooking were also carried out. A theoretical modeling was developed by setting up different heat balancing equations and a reasonable agreement between theoretical computed values and the experimental values was observed. © 2002 Published by Elsevier Science Ltd.

1. Introduction

Compound parabolic concentrators for a flat absorber, which consists of curved segments, is one which forms parts of two parabolas. Many improvements in the design and performance of the CPC collector have been made since its invention in

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Nomenclature

A	Area
CPC	Compound Parabolic Concentrator
CR	Concentration ratio
C_w	Specificheat of water
F	Heat transfer factor
g	gap thickness
h	height
I	Solar irradiance
L	Length, latent heat of vaporization
m	Mass
$m^{\cdot}$	Mass flow rate
$<n>$	Average number of reflections
p	Gap loss factor
q	Rate of energy
r	Radius
r_1	Radius of the receiver
r_2	Radius of envelope
T	temperature
t	time
U_L	heat loss coefficient

Greek Letter

α	Absorptance
δ	Gap thickness
ε	Infrared emittance
η	Efficiency
ρ	Reflectance, density, length of tangent
τ	Transmittance
θ_A	Half acceptance angle
θ_{in}	Incident angle
ΔT	Difference in temperature

1974 [1]. The CPC reflector profile for a tubular absorber is such that the reflector touches the absorber at the cusp region. This results in conductive heat losses. So a gap between the tubular absorber and the reflector has to be created to prevent conductor heat losses from absorber to metallic reflector, and also for providing a glass envelope around the absorber, which will improve the thermal efficiency of the CPC module at high temperatures. However, the gap between the absorber and