DESIGN, PERFORMANCE ANALYSIS, AND MANUFACTURING OF PARABOLIC TROUGH SOLAR COLLECTOR USED FOR THERMAL LOADS

By

Eng. Mohamed Rashed Helmy AbdelMagid

A Thesis Submitted to the Faculty of
Engineering at Cairo University in Partial
Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE

In

MECHANICAL POWER ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under Supervision of

AbdAlla Sayed Hanafi
Professor
in Mechanical Power
Engineering Department.
Faculty of Engineering,
Cairo University.

Hatem Omar Haridy
Assistant Professor
in Mechanical Power
Engineering Department.
Faculty of Engineering,
Cairo University.

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Approved by the Examining committee

Prof. Dr. Abdalla Sayed Hanafi (Main Advisor and a Member)
Mechanical Power Engineering Dep., Faculty of Engineering, Cairo University

Prof. Dr. Abdel -Wahed El-Dib (Member)
Mechanical Power Engineering Dep., Faculty of Engineering, Cairo University

Prof. Dr. Osama Ezzat Abdellatif (Member)
Mechanical Power Engineering Dep., Faculty of Engineering, Benha University

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2015

Engineer: Mohamed Rashed Helmy

Date of Birth: 18/09/1986

Nationality: Egyptian

E-mail: engmohrashed@gmail.com

Address: 6th of October, Giza, Egypt.

Registration Date: 01/10/2011

Awarding Date: / /2015

Degree: Master of Science

Department: Mechanical Power Engineering

Supervisors: Prof. Dr. Abdalla Sayed Hanafi

Dr. Hatem Omar Haridy

Examiners: Prof. Dr. Abdalla Sayed Hanafi

Prof. Dr. Abdel-Wahed El-Dib

Prof. Dr. Osama Ezzat Abdellatif (Mechanical Power Department, Faculty of Engineering, Benha University)

Thesis Title: DESIGN, PERFORMANCE ANALYSIS, AND MANUFACTURING OF PARABOLIC TROUGH SOLAR COLLECTOR USED FOR THERMAL LOADS.

Keywords: Parabolic trough collector, Intercept factor, Optical efficiency, Shading factor, End loss factor.

Summary: This thesis presents a detailed study on Parabolic Trough Solar Collectors applied with a water desalination unit using a multi-effect distillation technique. Thermal design procedures were implemented to determine the full dimensions of the collector. Then, optical and thermal losses from the collector were investigated taking into consideration the shading effect and the end loss factor. Also, transient thermal performance of the collector was studied throughout the annual seasons. It was found that the best performance will be achieved in May during which the desalination unit can be solar operated for seven hours daily, producing 15 m^3/day of distillate water. Finally, the construction, manufacturing, and assembly steps of the parabolic trough collector were introduced.

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Nomenclature

Symbol	**Quantity**
$A_{aperture}$	Aperture Area, m^2
a	Accommodation Coefficient
b	Interaction Coefficient
c	Specific Heat, kJ/kg.K
C	Concentration Ratio
D	Receiver Diameter
d_D	Distance between the two units
d_r	Displacement of the receiver from the focus
d*	Universal non-random error due to receiver dislocation
f	Focal Length
f	Friction Factor
h	Heat Transfer Coefficient, $W/m^2.K$
k	Thermal Conductivity, W/m.K
k(θ)	Incidence Angle Modifier
L	Collector Length, m
l	Un-illuminated Length of the receiver, m
l_{win}	Illuminated length of the second receiver, m
m	Oil mass, kg
n	Day number of the year
Nu	Nusselt Number
Pr	Prandtl number
$\dot{Q}_{absorbed}$	Solar irradiance absorbed by the receiver tube, W/m^2
$\dot{Q}_{heatloss}$	Solar irradiance loss by the receiver tube, W/m^2
$\dot{Q}_{Load}$	The steam generator load, W
$\dot{Q}_{useful}$	The useful energy carried by the heat transfer fluid, W
q'_{12conv}	Heat flux by convection from the receiver to the HTF, W/m

q'_{23cond}	Heat flux by conduction in the receiver tube, W/m
$q'_{3SolAbs}$	Heat flux absorbed by the receiver tube, W/m
q'_{34conv}	Heat flux by convection from the receiver to the glazing, W/m
q'_{34rad}	Heat flux by radiation from the receiver to the glazing, W/m
q'_{45cond}	Heat flux by conduction in the glass glazing, W/m
$q'_{5SolAbs}$	Heat flux absorbed by the glass glazing, W/m
q'_{56conv}	Heat flux by convection from the glazing to ambient, W/m
q'_{57rad}	Heat flux by radiation from the glazing to the sky, W/m
$q'_{cond,bracket}$	Heat flux loss in the supporting brackets, W/m
$q'_{heatloss}$	Heat flux loss from the receiver tube, W/m
Ra	Rayleigh Number
Re	Reynolds Number
t	Time, hrs
T	Temperature, K
T_6	Ambient Temperature, K
T_7	Effective Sky Temperature, K
U	Overall Heat Transfer Coefficient, $W/m^2.K$
W	Total Aperture Width, m
W_{eff}	Un-shaded Aperture Width, m
X	Shading Width, m

Greek Letters

Φ_r	Rim Angle
Φ	Latitude angle
Ϭ	Stefan-Boltzmann constant
σ	Standard deviation of random errors
σ*	Universal parameter for random errors
β	Tracking angle error
β*	Universal parameter for tracking error
γ	Intercept Factor
θ	Incidence Angle

δ	Declination angle
ω	Hour angle
γ_s	Solar azimuth angle
ψ	Orientation angle
ζ	Tracking angle
ρ	Mirror reflectivity
τ	Glazing transmisivity
α	Receiver absorbtivity
η_o	Optical efficiency
ε	Emissivity